OpenShift Container Platform 4.11

Installing

Installing and configuring OpenShift Container Platform clusters

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Legal Notice

Abstract

This document provides information about installing OpenShift Container Platform and details about some configuration processes.

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CHAPTER 1. OPENSHIFT CONTAINER PLATFORM INSTALLATION OVERVIEW

1.1. ABOUT OPENSHIFT CONTAINER PLATFORM INSTALLATION

You can harness the flexibility of the OpenShift Container Platform installation program to install a cluster. You can use the program in the following ways:

- Deploy a cluster on provisioned infrastructure.
- Deploy a cluster on infrastructure that you prepare and maintain.

The following list details two types of basic OpenShift Container Platform clusters:

- Installer-provisioned infrastructure clusters.
- User-provisioned infrastructure clusters.

Both cluster types have the following characteristics:

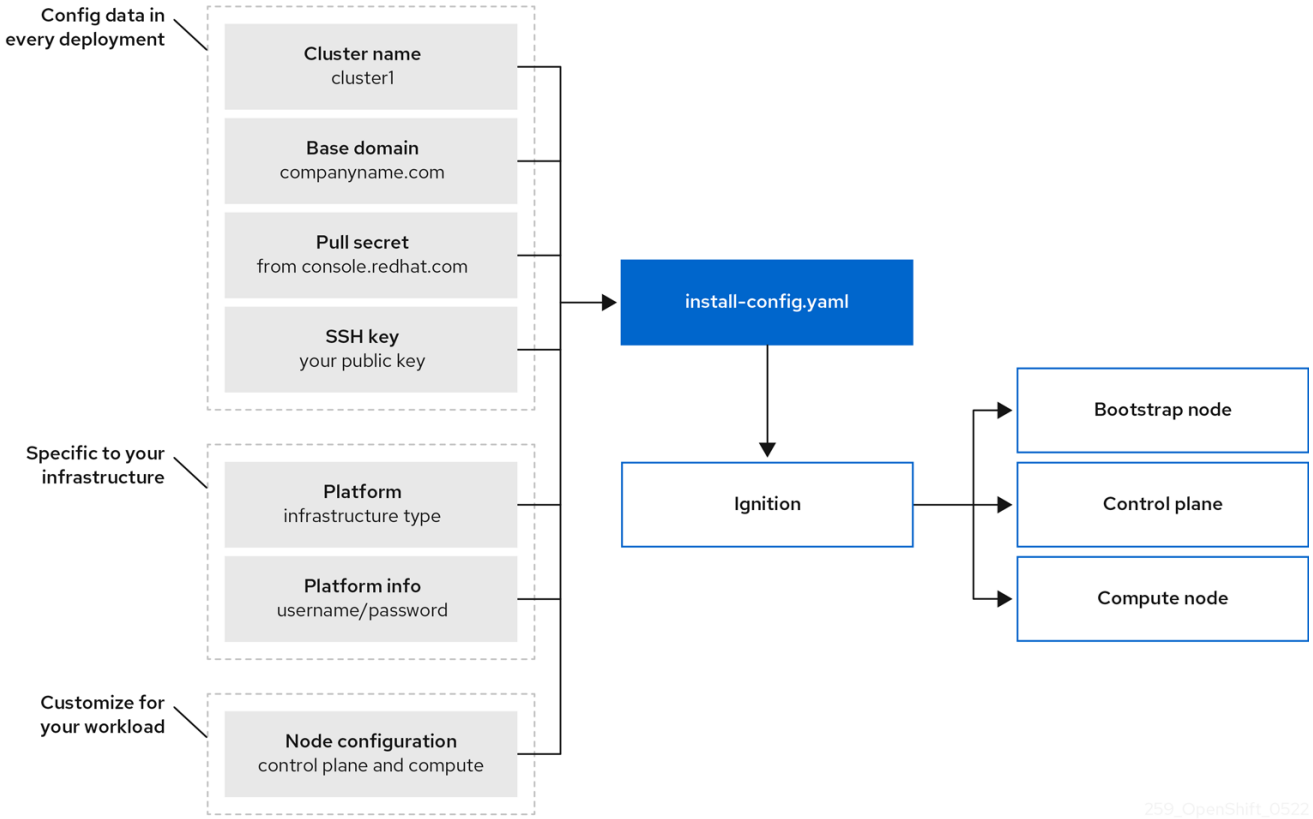
- Highly available infrastructure with no single points of failure, which is available by default.
- Administrators can control updates, such as the update mechanism and schedule.

1.1.1. About the installation program

You can use the installation program to deploy each type of cluster. The installation program generates the main assets, such as Ignition config files for the bootstrap, control plane, and compute machines. You can start an OpenShift Container Platform cluster with these three machine configurations, provided you correctly configured the infrastructure.

The OpenShift Container Platform installation program uses a set of targets and dependencies to manage cluster installations. The installation program has a set of targets that it must achieve, and each target has a set of dependencies. Because each target is only concerned with its own dependencies, the installation program can act to achieve multiple targets in parallel with the ultimate target being a running cluster. The installation program recognizes and uses existing components instead of running commands to create them again because the program meets the dependencies.

Figure 1.1. OpenShift Container Platform installation targets and dependencies



1.1.2. About Red Hat Enterprise Linux CoreOS (RHCOS)

Post-installation, each cluster machine uses Red Hat Enterprise Linux CoreOS (RHCOS) as the operating system. RHCOS is the immutable container host version of Red Hat Enterprise Linux (RHEL) and features a RHEL kernel with SELinux enabled by default. RHCOS includes the **kubelet**, which is the Kubernetes node agent, and the CRI-O container runtime, which is optimized for Kubernetes.

Every control plane machine in an OpenShift Container Platform 4.11 cluster must use RHCOS, which includes a critical first-boot provisioning tool called Ignition. This tool enables the cluster to configure the machines. Operating system updates are delivered as a bootable container image, using **OSTree** as a backend, that is deployed across the cluster by the Machine Config Operator. Actual operating system changes are made in-place on each machine as an atomic operation by using **rpm-ostree**. Together, these technologies enable OpenShift Container Platform to manage the operating system like it manages any other application on the cluster, by in-place upgrades that keep the entire platform up to date. These in-place updates can reduce the burden on operations teams.

If you use RHCOS as the operating system for all cluster machines, the cluster manages all aspects of its components and machines, including the operating system. Because of this, only the installation program and the Machine Config Operator can change machines. The installation program uses Ignition config files to set the exact state of each machine, and the Machine Config Operator completes more changes to the machines, such as the application of new certificates or keys, after installation.

1.1.3. Glossary of common terms for OpenShift Container Platform installing

The glossary defines common terms that relate to the installation content. Read the following list of terms to better understand the installation process.

Bootstrap node

A temporary machine that runs a minimal Kubernetes configuration required to deploy the OpenShift Container Platform control plane.

Control plane

A container orchestration layer that exposes the API and interfaces to define, deploy, and manage the lifecycle of containers. Also known as control plane machines.

Compute node

Nodes that are responsible for executing workloads for cluster users. Also known as worker nodes.

Disconnected installation

In some situations, parts of a data center might not have access to the internet, even through proxy servers. You can still install the OpenShift Container Platform in these environments, but you must download the required software and images and make them available to the disconnected environment.

The OpenShift Container Platform installation program

A program that provisions the infrastructure and deploys a cluster.

Installer-provisioned infrastructure

The installation program deploys and configures the infrastructure that the cluster runs on.

Ignition config files

A file that the Ignition tool uses to configure Red Hat Enterprise Linux CoreOS (RHCOS) during operating system initialization. The installation program generates different Ignition configuration files to initialize bootstrap, control plane, and worker nodes.

Kubernetes manifests

Specifications of a Kubernetes API object in a JSON or YAML format. A configuration file can include deployments, config maps, secrets, daemonsets, and so on.

Kubelet

A primary node agent that runs on each node in the cluster to ensure that containers are running in a pod.

Load balancers

A load balancer serves as the single point of contact for clients. Load balancers for the API distribute incoming traffic across control plane nodes.

Machine Config Operator

An Operator that manages and applies configurations and updates of the base operating system and container runtime, including everything between the kernel and kubelet, for the nodes in the cluster.

Operators

The preferred method of packaging, deploying, and managing a Kubernetes application in an OpenShift Container Platform cluster. An operator takes human operational knowledge and encodes it into software that is easily packaged and shared with customers.

User-provisioned infrastructure

You can install OpenShift Container Platform on infrastructure that you provide. You can use the installation program to generate the assets required to provision the cluster infrastructure, create the cluster infrastructure, and then deploy the cluster to the infrastructure that you provided.

1.1.4. Installation process

When you install an OpenShift Container Platform cluster, you download the installation program from the appropriate **Cluster Type** page on the OpenShift Cluster Manager Hybrid Cloud Console. This console manages:

- REST API for accounts.
- Registry tokens, which are the pull secrets that you use to obtain the required components.
- Cluster registration, which associates the cluster identity to your Red Hat account to facilitate the gathering of usage metrics.

In OpenShift Container Platform 4.11, the installation program is a Go binary file that performs a series of file transformations on a set of assets. The way you interact with the installation program differs depending on your installation type. Consider the following installation use cases:

- For clusters with installer-provisioned infrastructure, you delegate the infrastructure bootstrapping and provisioning to the installation program instead of doing it yourself. The installation program creates all of the networking, machines, and operating systems that are required to support the cluster.
- If you provision and manage the infrastructure for your cluster, you must provide all of the cluster infrastructure and resources, including the bootstrap machine, networking, load balancing, storage, and individual cluster machines.

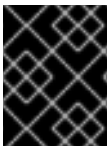
You use three sets of files during installation: an installation configuration file that is named **install-config.yaml**, Kubernetes manifests, and Ignition config files for your machine types.

IMPORTANT

You can modify Kubernetes and the Ignition config files that control the underlying RHCOS operating system during installation. However, no validation is available to confirm the suitability of any modifications that you make to these objects. If you modify these objects, you might render your cluster non-functional. Because of this risk, modifying Kubernetes and Ignition config files is not supported unless you are following documented procedures or are instructed to do so by Red Hat support.

The installation configuration file is transformed into Kubernetes manifests, and then the manifests are wrapped into Ignition config files. The installation program uses these Ignition config files to create the cluster.

The installation configuration files are all pruned when you run the installation program, so be sure to back up all the configuration files that you want to use again.



IMPORTANT

You cannot modify the parameters that you set during installation, but you can modify many cluster attributes after installation.

The installation process with installer-provisioned infrastructure

The default installation type uses installer-provisioned infrastructure. By default, the installation program acts as an installation wizard, prompting you for values that it cannot determine on its own and providing reasonable default values for the remaining parameters. You can also customize the installation process to support advanced infrastructure scenarios. The installation program provisions the underlying infrastructure for the cluster.

You can install either a standard cluster or a customized cluster. With a standard cluster, you provide minimum details that are required to install the cluster. With a customized cluster, you can specify more details about the platform, such as the number of machines that the control plane uses, the type of virtual machine that the cluster deploys, or the CIDR range for the Kubernetes service network.

If possible, use this feature to avoid having to provision and maintain the cluster infrastructure. In all other environments, you use the installation program to generate the assets that you require to provision your cluster infrastructure.

With installer-provisioned infrastructure clusters, OpenShift Container Platform manages all aspects of the cluster, including the operating system itself. Each machine boots with a configuration that references resources hosted in the cluster that it joins. This configuration allows the cluster to manage itself as updates are applied.

The installation process with user-provisioned infrastructure
You can also install OpenShift Container Platform on infrastructure that you provide. You use the installation program to generate the assets that you require to provision the cluster infrastructure, create the cluster infrastructure, and then deploy the cluster to the infrastructure that you provided.

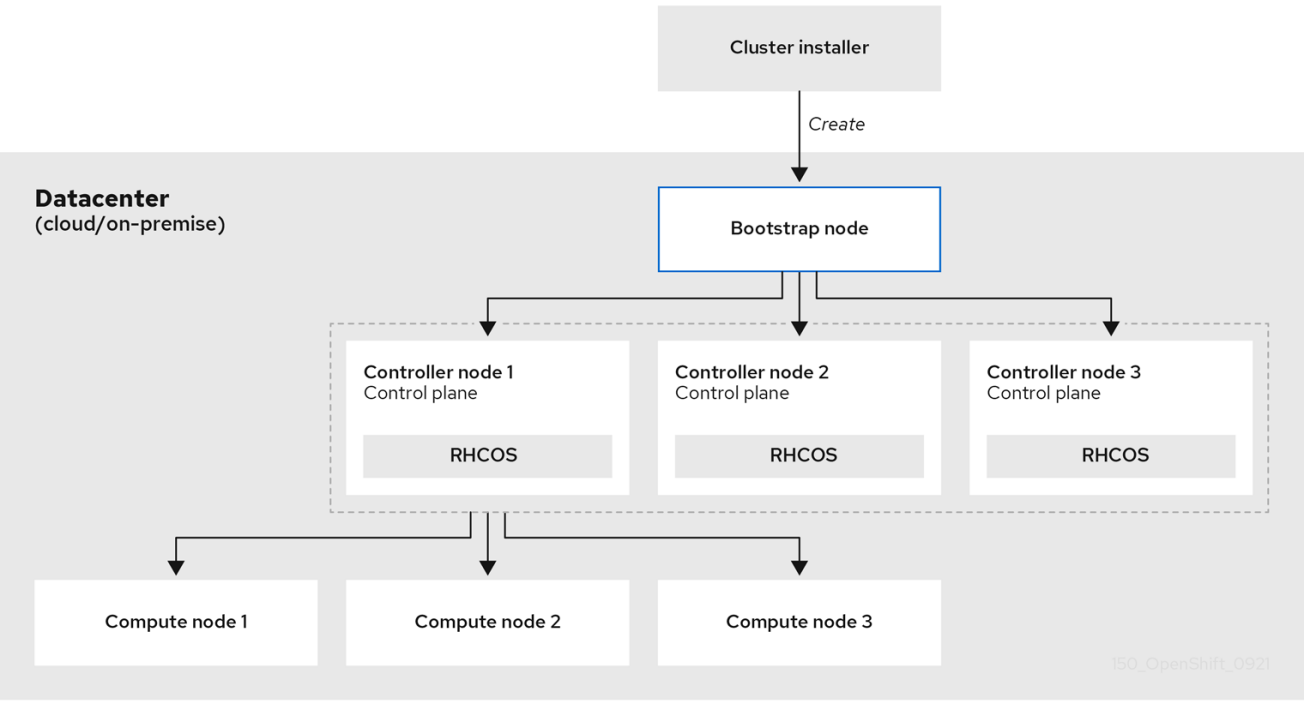
If you do not use infrastructure that the installation program provisioned, you must manage and maintain the cluster resources yourself. The following list details some of these self-managed resources:

- The underlying infrastructure for the control plane and compute machines that make up the cluster
- Load balancers
- Cluster networking, including the DNS records and required subnets
- Storage for the cluster infrastructure and applications

If your cluster uses user-provisioned infrastructure, you have the option of adding RHEL compute machines to your cluster.

Installation process details
When a cluster is provisioned, each machine in the cluster requires information about the cluster. OpenShift Container Platform uses a temporary bootstrap machine during initial configuration to provide the required information to the permanent control plane. The temporary bootstrap machine boots by using an Ignition config file that describes how to create the cluster. The bootstrap machine creates the control plane machines that make up the control plane. The control plane machines then create the compute machines, which are also known as worker machines. The following figure illustrates this process:

Figure 1.2. Creating the bootstrap, control plane, and compute machines



After the cluster machines initialize, the bootstrap machine is destroyed. All clusters use the bootstrap process to initialize the cluster, but if you provision the infrastructure for your cluster, you must complete many of the steps manually.

IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- Consider using Ignition config files within 12 hours after they are generated, because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

Bootstrapping a cluster involves the following steps:

1. The bootstrap machine boots and starts hosting the remote resources required for the control plane machines to boot. If you provision the infrastructure, this step requires manual intervention.
2. The bootstrap machine starts a single-node etcd cluster and a temporary Kubernetes control plane.
3. The control plane machines fetch the remote resources from the bootstrap machine and finish booting. If you provision the infrastructure, this step requires manual intervention.

4. The temporary control plane schedules the production control plane to the production control plane machines.
5. The Cluster Version Operator (CVO) comes online and installs the etcd Operator. The etcd Operator scales up etcd on all control plane nodes.
6. The temporary control plane shuts down and passes control to the production control plane.
7. The bootstrap machine injects OpenShift Container Platform components into the production control plane.
8. The installation program shuts down the bootstrap machine. If you provision the infrastructure, this step requires manual intervention.
9. The control plane sets up the compute nodes.
10. The control plane installs additional services in the form of a set of Operators.

The result of this bootstrapping process is a running OpenShift Container Platform cluster. The cluster then downloads and configures remaining components needed for the day-to-day operations, including the creation of compute machines in supported environments.

1.1.5. Verifying node state after installation

The OpenShift Container Platform installation completes when the following installation health checks are successful:

- The provisioner can access the OpenShift Container Platform web console.
- All control plane nodes are ready.
- All cluster Operators are available.

NOTE

After the installation completes, the specific cluster Operators responsible for the worker nodes continuously attempt to provision all worker nodes. Some time is required before all worker nodes report as **READY**. For installations on bare metal, wait a minimum of 60 minutes before troubleshooting a worker node. For installations on all other platforms, wait a minimum of 40 minutes before troubleshooting a worker node. A **DEGRADED** state for the cluster Operators responsible for the worker nodes depends on the Operators' own resources and not on the state of the nodes.

After your installation completes, you can continue to monitor the condition of the nodes in your cluster.

Prerequisites

- The installation program resolves successfully in the terminal.

Procedure

1. Show the status of all worker nodes:

```
$ oc get nodes
```

Example output

```
NAME                         STATUS   ROLES    AGE   VERSION
example-compute1.example.com   Ready    worker   13m   v1.21.6+bb8d50a
example-compute2.example.com   Ready    worker   13m   v1.21.6+bb8d50a
example-compute4.example.com   Ready    worker   14m   v1.21.6+bb8d50a
example-control1.example.com   Ready    master   52m   v1.21.6+bb8d50a
example-control2.example.com   Ready    master   55m   v1.21.6+bb8d50a
example-control3.example.com   Ready    master   55m   v1.21.6+bb8d50a
```

2. Show the phase of all worker machine nodes:

```
$ oc get machines -A
```

Example output

```
NAMESPACE               NAME                        PHASE       TYPE   REGION   ZONE   AGE
openshift-machine-api   example-zbbt6-master-0      Running                          95m
openshift-machine-api   example-zbbt6-master-1      Running                          95m
openshift-machine-api   example-zbbt6-master-2      Running                          95m
openshift-machine-api   example-zbbt6-worker-0-25bhp   Running                       49m
openshift-machine-api   example-zbbt6-worker-0-8b4c2   Running                       49m
openshift-machine-api   example-zbbt6-worker-0-jkbqt   Running                       49m
openshift-machine-api   example-zbbt6-worker-0-qrl5b   Running                       49m
```

Additional resources

- Getting the BareMetalHost resource
- Following the installation
- Validating an installation

Installation scope

The scope of the OpenShift Container Platform installation program is intentionally narrow. It is designed for simplicity and ensured success. You can complete many more configuration tasks after installation completes.

Additional resources

- See Available cluster customizations for details about OpenShift Container Platform configuration resources.

1.1.6. OpenShift Local overview

OpenShift Local supports rapid application development to get started building OpenShift Container Platform clusters. OpenShift Local is designed to run on a local computer to simplify setup and testing, and to emulate the cloud development environment locally with all of the tools needed to develop container-based applications.

Regardless of the programming language you use, OpenShift Local hosts your application and brings a minimal, preconfigured Red Hat OpenShift Container Platform cluster to your local PC without the need for a server-based infrastructure.

On a hosted environment, OpenShift Local can create microservices, convert them into images, and run them in Kubernetes-hosted containers directly on your laptop or desktop running Linux, macOS, or Windows 10 or later.

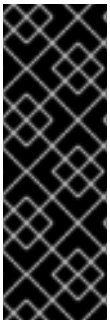
For more information about OpenShift Local, see Red Hat OpenShift Local Overview .

1.2. SUPPORTED PLATFORMS FOR OPENSHIFT CONTAINER PLATFORM CLUSTERS

In OpenShift Container Platform 4.11, you can install a cluster that uses installer-provisioned infrastructure on the following platforms:

- Alibaba Cloud
- Amazon Web Services (AWS)
- Bare metal
- Google Cloud Platform (GCP)
- IBM Cloud® VPC
- Microsoft Azure
- Microsoft Azure Stack Hub
- Nutanix
- Red Hat OpenStack Platform (RHOSP)
    - The latest OpenShift Container Platform release supports both the latest RHOSP long-life release and intermediate release. For complete RHOSP release compatibility, see the OpenShift Container Platform on RHOSP support matrix .
- VMware Cloud (VMC) on AWS
- VMware vSphere

For these clusters, all machines, including the computer that you run the installation process on, must have direct internet access to pull images for platform containers and provide telemetry data to Red Hat.



IMPORTANT

After installation, the following changes are not supported:

- Mixing cloud provider platforms.
- Mixing cloud provider components. For example, using a persistent storage framework from a another platform on the platform where you installed the cluster.

In OpenShift Container Platform 4.11, you can install a cluster that uses user-provisioned infrastructure on the following platforms:

- AWS

- Azure
- Azure Stack Hub
- Bare metal
- GCP
- IBM Power
- IBM Z or IBM® LinuxONE
- RHOSP
    - The latest OpenShift Container Platform release supports both the latest RHOSP long-life release and intermediate release. For complete RHOSP release compatibility, see the OpenShift Container Platform on RHOSP support matrix .
- VMware Cloud on AWS
- VMware vSphere

Depending on the supported cases for the platform, you can perform installations on user-provisioned infrastructure, so that you can run machines with full internet access, place your cluster behind a proxy, or perform a disconnected installation.

In a disconnected installation, you can download the images that are required to install a cluster, place them in a mirror registry, and use that data to install your cluster. While you require internet access to pull images for platform containers, with a disconnected installation on vSphere or bare metal infrastructure, your cluster machines do not require direct internet access.

The OpenShift Container Platform 4.x Tested Integrations page contains details about integration testing for different platforms.

Additional resources

- See Supported installation methods for different platforms for more information about the types of installations that are available for each supported platform.
- See Selecting a cluster installation method and preparing it for users for information about choosing an installation method and preparing the required resources.

CHAPTER 2. SELECTING A CLUSTER INSTALLATION METHOD AND PREPARING IT FOR USERS

Before you install OpenShift Container Platform, decide what kind of installation process to follow and make sure you that you have all of the required resources to prepare the cluster for users.

2.1. SELECTING A CLUSTER INSTALLATION TYPE

Before you install an OpenShift Container Platform cluster, you need to select the best installation instructions to follow. Think about your answers to the following questions to select the best option.

2.1.1. Do you want to install and manage an OpenShift Container Platform cluster yourself?

If you want to install and manage OpenShift Container Platform yourself, you can install it on the following platforms:

- Alibaba Cloud
- Amazon Web Services (AWS) on 64-bit x86 instances
- Amazon Web Services (AWS) on 64-bit ARM instances
- Microsoft Azure
- Microsoft Azure Stack Hub
- Google Cloud Platform (GCP)
- Red Hat OpenStack Platform (RHOSP)
- Red Hat Virtualization (RHV)
- IBM Cloud VPC
- IBM Z and LinuxONE
- IBM Z and LinuxONE for Red Hat Enterprise Linux (RHEL) KVM
- IBM Power
- Nutanix
- VMware vSphere
- VMware Cloud (VMC) on AWS
- Bare metal or other platform agnostic infrastructure

You can deploy an OpenShift Container Platform 4 cluster to both on-premise hardware and to cloud hosting services, but all of the machines in a cluster must be in the same datacenter or cloud hosting service.

If you want to use OpenShift Container Platform but do not want to manage the cluster yourself, you have several managed service options. If you want a cluster that is fully managed by Red Hat, you can use

OpenShift Dedicated or OpenShift Online. You can also use OpenShift as a managed service on Azure, AWS, IBM Cloud VPC, or Google Cloud. For more information about managed services, see the OpenShift Products page. If you install an OpenShift Container Platform cluster with a cloud virtual machine as a virtual bare metal, the corresponding cloud-based storage is not supported.

2.1.2. Have you used OpenShift Container Platform 3 and want to use OpenShift Container Platform 4?

If you used OpenShift Container Platform 3 and want to try OpenShift Container Platform 4, you need to understand how different OpenShift Container Platform 4 is. OpenShift Container Platform 4 weaves the Operators that package, deploy, and manage Kubernetes applications and the operating system that the platform runs on, Red Hat Enterprise Linux CoreOS (RHCOS), together seamlessly. Instead of deploying machines and configuring their operating systems so that you can install OpenShift Container Platform on them, the RHCOS operating system is an integral part of the OpenShift Container Platform cluster. Deploying the operating system for the cluster machines is part of the installation process for OpenShift Container Platform. See Differences between OpenShift Container Platform 3 and 4 .

Because you need to provision machines as part of the OpenShift Container Platform cluster installation process, you cannot upgrade an OpenShift Container Platform 3 cluster to OpenShift Container Platform 4. Instead, you must create a new OpenShift Container Platform 4 cluster and migrate your OpenShift Container Platform 3 workloads to them. For more information about migrating, see Migrating from OpenShift Container Platform 3 to 4 overview . Because you must migrate to OpenShift Container Platform 4, you can use any type of production cluster installation process to create your new cluster.

2.1.3. Do you want to use existing components in your cluster?

Because the operating system is integral to OpenShift Container Platform, it is easier to let the installation program for OpenShift Container Platform stand up all of the infrastructure. These are called *installer provisioned infrastructure* installations. In this type of installation, you can provide some existing infrastructure to the cluster, but the installation program deploys all of the machines that your cluster initially needs.

You can deploy an installer-provisioned infrastructure cluster without specifying any customizations to the cluster or its underlying machines to Alibaba Cloud, AWS, Azure, Azure Stack Hub, GCP, Nutanix, or VMC on AWS. These installation methods are the fastest way to deploy a production-capable OpenShift Container Platform cluster.

If you need to perform basic configuration for your installer-provisioned infrastructure cluster, such as the instance type for the cluster machines, you can customize an installation for Alibaba Cloud, AWS, Azure, GCP, Nutanix, or VMC on AWS.

For installer-provisioned infrastructure installations, you can use an existing VPC in AWS, vNet in Azure, or VPC in GCP. You can also reuse part of your networking infrastructure so that your cluster in AWS, Azure, GCP, or VMC on AWS can coexist with existing IP address allocations in your environment and integrate with existing MTU and VXLAN configurations. If you have existing accounts and credentials on these clouds, you can re-use them, but you might need to modify the accounts to have the required permissions to install OpenShift Container Platform clusters on them.

You can use the installer-provisioned infrastructure method to create appropriate machine instances on your hardware for RHOSP, RHOSP with Kuryr, RHV, vSphere, and bare metal. Additionally, for vSphere, VMC on AWS, you can also customize additional network parameters during installation.

If you want to reuse extensive cloud infrastructure, you can complete a *user-provisioned infrastructure* installation. With these installations, you manually deploy the machines that your cluster requires during the installation process. If you perform a user-provisioned infrastructure installation on AWS, Azure,

Azure Stack Hub, GCP, or VMC on AWS, you can use the provided templates to help you stand up all of the required components. You can also reuse a shared VPC on GCP. Otherwise, you can use the provider-agnostic installation method to deploy a cluster into other clouds.

You can also complete a user-provisioned infrastructure installation on your existing hardware. If you use RHOSP, RHV, IBM Z or LinuxONE, IBM Z or LinuxONE with RHEL KVM, IBM Power, or vSphere, use the specific installation instructions to deploy your cluster. If you use other supported hardware, follow the bare metal installation procedure. For some of these platforms, such as RHOSP, vSphere, VMC on AWS, and bare metal, you can also customize additional network parameters during installation.

2.1.4. Do you need extra security for your cluster?

If you use a user-provisioned installation method, you can configure a proxy for your cluster. The instructions are included in each installation procedure.

If you want to prevent your cluster on a public cloud from exposing endpoints externally, you can deploy a private cluster with installer-provisioned infrastructure on AWS, Azure, or GCP.

If you need to install your cluster that has limited access to the internet, such as a disconnected or restricted network cluster, you can mirror the installation packages and install the cluster from them. Follow detailed instructions for user provisioned infrastructure installations into restricted networks for AWS, GCP, IBM Z or LinuxONE, IBM Z or LinuxONE with RHEL KVM, IBM Power, vSphere, VMC on AWS, or bare metal. You can also install a cluster into a restricted network using installer-provisioned infrastructure by following detailed instructions for AWS, GCP, VMC on AWS, RHOSP, RHV, and vSphere.

If you need to deploy your cluster to an AWS GovCloud region, AWS China region, or Azure government region, you can configure those custom regions during an installer-provisioned infrastructure installation.

You can also configure the cluster machines to use FIPS Validated / Modules in Process cryptographic libraries during installation.

IMPORTANT

The use of FIPS Validated / Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.

2.2. PREPARING YOUR CLUSTER FOR USERS AFTER INSTALLATION

Some configuration is not required to install the cluster but recommended before your users access the cluster. You can customize the cluster itself by customizing the Operators that make up your cluster and integrate you cluster with other required systems, such as an identity provider.

For a production cluster, you must configure the following integrations:

- Persistent storage
- An identity provider
- Monitoring core OpenShift Container Platform components

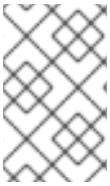
2.3. PREPARING YOUR CLUSTER FOR WORKLOADS

Depending on your workload needs, you might need to take extra steps before you begin deploying

applications. For example, after you prepare infrastructure to support your application build strategy, you might need to make provisions for low-latency workloads or to protect sensitive workloads. You can also configure monitoring for application workloads. If you plan to run Windows workloads, you must enable hybrid networking with OVN-Kubernetes during the installation process; hybrid networking cannot be enabled after your cluster is installed.

2.4. SUPPORTED INSTALLATION METHODS FOR DIFFERENT PLATFORMS

You can perform different types of installations on different platforms.



NOTE

Not all installation options are supported for all platforms, as shown in the following tables. A checkmark indicates that the option is supported and links to the relevant section.

Table 2.1. Installer-provisioned infrastructure options

	Alibaba	AWS(64-bit x86)	AWS(64-bit ARM)	Azure	Azure Stack Hub	GCP	Nutanix	RHOSP	RHV	Bare metal (64-bit x86)	Bare metal (64-bit ARM)	vSphere	VMC	IBM Cloud VPC	IBM Z	IBM Power
Default	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓		
Custom	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓		
Network customization	✓	✓	✓	✓	✓	✓		✓				✓	✓	✓		

	Alibaba	AWS(64-bit x86)	AWS(64-bit ARM)	Azure	Azure Stack Hub	GCP	Nutanix	RHOSP	RHV	Bare metal (64-bit x86)	Bare metal (64-bit ARM)	vSphere	VMC	IBM Cloud VPC	IBM Z	IBM Power
Restricted network		✓	✓			✓		✓	✓	✓	✓	✓	✓			
Private clusters		✓	✓	✓		✓										
Existing virtual private networks		✓	✓	✓		✓										
Government regions		✓		✓												

	Alibaba	AWS(64-bit x86)	AWS(64-bit ARM)	Azure	Azure Stack Hub	GCP	Nutanix	RHOSP	RHV	Baremetal (64-bit x86)	Baremetal (64-bit ARM)	vSphere	VMC	IBM Cloud VPC	IBM Z	IBM Power
Secret regions		✓														
China regions		✓														

Table 2.2. User-provisioned infrastructure options

	Alibaba	AWS (64-bit x86)	AWS (64-bit ARM)	Azure	Azure Stack Hub	GCP	Nutanix	RHOSP	RHV	Bare metal (64-bit x86)	Bare metal (64-bit ARM)	vSphere	VMC	IBM Cloud VPC	IBM Z	IBM Z with RHEL KVM	IBM Power	Platform agnostic
Custom		✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓		✓	✓	✓	✓

	Alibaba	AWS (64-bit x86)	AWS (64-bit ARM)	Azure	Azure Stack Hub	GCP	Nutanix	RHOSP	RHV	Bare metal (64-bit x86)	Bare metal (64-bit ARM)	vSphere	VMC	IBM Cloud VPC	IBM Z	IBM Z with RHEL KVM	IBM Power	Platform agnostic
Network customization								✓		✓	✓	✓	✓					
Restricted network		✓	✓			✓			✓	✓		✓	✓		✓	✓	✓	

	Alibaba	AWS (64-bit x86)	AWS (64-bit ARM)	Azure	Azure Stack Hub	GCP	Nutanix	RHOSP	RHV	Bare metal (64-bit x86)	Bare metal (64-bit ARM)	vSphere	VMC	IBM Cloud VPC	IBM Z	IBM Z with RHEL KVM	IBM Power	Platform agnostic
Shared VPC hosted outside of cluster project						✓												

CHAPTER 3. DISCONNECTED INSTALLATION MIRRORING

3.1. ABOUT DISCONNECTED INSTALLATION MIRRORING

You can use a mirror registry to ensure that your clusters only use container images that satisfy your organizational controls on external content. Before you install a cluster on infrastructure that you provision in a restricted network, you must mirror the required container images into that environment. To mirror container images, you must have a registry for mirroring.

3.1.1. Creating a mirror registry

If you already have a container image registry, such as Red Hat Quay, you can use it as your mirror registry. If you do not already have a registry, you can create a mirror registry using the *mirror registry for Red Hat OpenShift*.

3.1.2. Mirroring images for a disconnected installation

You can use one of the following procedures to mirror your OpenShift Container Platform image repository to your mirror registry:

- Mirroring images for a disconnected installation
- Mirroring images for a disconnected installation using the oc-mirror plugin

3.2. CREATING A MIRROR REGISTRY WITH MIRROR REGISTRY FOR RED HAT OPENSHIFT

The *mirror registry for Red Hat OpenShift* is a small and streamlined container registry that you can use as a target for mirroring the required container images of OpenShift Container Platform for disconnected installations.

If you already have a container image registry, such as Red Hat Quay, you can skip this section and go straight to Mirroring the OpenShift Container Platform image repository .

3.2.1. Prerequisites

- An OpenShift Container Platform subscription.
- Red Hat Enterprise Linux (RHEL) 8 and 9 with Podman 3.3 and OpenSSL installed.
- Fully qualified domain name for the Red Hat Quay service, which must resolve through a DNS server.
- Key-based SSH connectivity on the target host. SSH keys are automatically generated for local installs. For remote hosts, you must generate your own SSH keys.
- 2 or more vCPUs.
- 8 GB of RAM.
- About 12 GB for OpenShift Container Platform 4.11 release images, or about 358 GB for OpenShift Container Platform 4.11 release images and OpenShift Container Platform 4.11 Red Hat Operator images. Up to 1 TB per stream or more is suggested.

IMPORTANT

These requirements are based on local testing results with only release images and Operator images. Storage requirements can vary based on your organization's needs. You might require more space, for example, when you mirror multiple z-streams. You can use standard Red Hat Quay functionality or the proper API callout to remove unnecessary images and free up space.

3.2.2. Mirror registry for Red Hat OpenShift introduction

For disconnected deployments of OpenShift Container Platform, a container registry is required to carry out the installation of the clusters. To run a production-grade registry service on such a cluster, you must create a separate registry deployment to install the first cluster. The *mirror registry for Red Hat OpenShift* addresses this need and is included in every OpenShift subscription. It is available for download on the OpenShift console **Downloads** page.

The *mirror registry for Red Hat OpenShift* allows users to install a small-scale version of Red Hat Quay and its required components using the **mirror-registry** command line interface (CLI) tool. The *mirror registry for Red Hat OpenShift* is deployed automatically with preconfigured local storage and a local database. It also includes auto-generated user credentials and access permissions with a single set of inputs and no additional configuration choices to get started.

The *mirror registry for Red Hat OpenShift* provides a pre-determined network configuration and reports deployed component credentials and access URLs upon success. A limited set of optional configuration inputs like fully qualified domain name (FQDN) services, superuser name and password, and custom TLS certificates are also provided. This provides users with a container registry so that they can easily create an offline mirror of all OpenShift Container Platform release content when running OpenShift Container Platform in restricted network environments.

Use of the *mirror registry for Red Hat OpenShift* is optional if another container registry is already available in the install environment.

3.2.2.1. Mirror registry for Red Hat OpenShift limitations

The following limitations apply to the *mirror registry for Red Hat OpenShift*:

- The *mirror registry for Red Hat OpenShift* is not a highly-available registry and only local file system storage is supported. It is not intended to replace Red Hat Quay or the internal image registry for OpenShift Container Platform.
- The *mirror registry for Red Hat OpenShift* is only supported for hosting images that are required to install a disconnected OpenShift Container Platform cluster, such as Release images or Red Hat Operator images. It uses local storage on your Red Hat Enterprise Linux (RHEL) machine, and storage supported by RHEL is supported by the *mirror registry for Red Hat OpenShift*.

NOTE

Because the *mirror registry for Red Hat OpenShift* uses local storage, you should remain aware of the storage usage consumed when mirroring images and use Red Hat Quay's garbage collection feature to mitigate potential issues. For more information about this feature, see "Red Hat Quay garbage collection".

- Support for Red Hat product images that are pushed to the *mirror registry for Red Hat OpenShift* for bootstrapping purposes are covered by valid subscriptions for each respective product. A list of exceptions to further enable the bootstrap experience can be found on the

Self-managed Red Hat OpenShift sizing and subscription guide .

- Content built by customers should not be hosted by the *mirror registry for Red Hat OpenShift* .
- Using the *mirror registry for Red Hat OpenShift* with more than one cluster is discouraged because multiple clusters can create a single point of failure when updating your cluster fleet. It is advised to leverage the *mirror registry for Red Hat OpenShift* to install a cluster that can host a production-grade, highly-available registry such as Red Hat Quay, which can serve OpenShift Container Platform content to other clusters.

3.2.3. Mirroring on a local host with mirror registry for Red Hat OpenShift

This procedure explains how to install the *mirror registry for Red Hat OpenShift* on a local host using the **mirror-registry** installer tool. By doing so, users can create a local host registry running on port 443 for the purpose of storing a mirror of OpenShift Container Platform images.

NOTE

Installing the *mirror registry for Red Hat OpenShift* using the **mirror-registry** CLI tool makes several changes to your machine. After installation, a **/etc/quay-install** directory is created, which has installation files, local storage, and the configuration bundle. Trusted SSH keys are generated in case the deployment target is the local host, and systemd files on the host machine are set up to ensure that container runtimes are persistent. Additionally, an initial user named **init** is created with an automatically generated password. All access credentials are printed at the end of the install routine.

Procedure

1. Download the **mirror-registry.tar.gz** package for the latest version of the *mirror registry for Red Hat OpenShift* found on the OpenShift console **Downloads** page.
2. Install the *mirror registry for Red Hat OpenShift* on your local host with your current user account by using the **mirror-registry** tool. For a full list of available flags, see "mirror registry for Red Hat OpenShift flags".

```
$ ./mirror-registry install \
  --quayHostname <host_example_com> \
  --quayRoot <example_directory_name>
```

3. Use the user name and password generated during installation to log into the registry by running the following command:

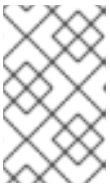
```
$ podman login -u init \
  -p <password> \
  <host_example_com>:8443> \
  --tls-verify=false 1
```

1 You can avoid running **--tls-verify=false** by configuring your system to trust the generated rootCA certificates. See "Using SSL to protect connections to Red Hat Quay" and "Configuring the system to trust the certificate authority" for more information.

NOTE

You can also log in by accessing the UI at **https://<host.example.com>:8443** after installation.

4. You can mirror OpenShift Container Platform images after logging in. Depending on your needs, see either the "Mirroring the OpenShift Container Platform image repository" or the "Mirroring Operator catalogs for use with disconnected clusters" sections of this document.

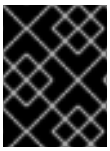


NOTE

If there are issues with images stored by the *mirror registry for Red Hat OpenShift* due to storage layer problems, you can remirror the OpenShift Container Platform images, or reinstall mirror registry on more stable storage.

3.2.4. Updating mirror registry for Red Hat OpenShift from a local host

This procedure explains how to update the *mirror registry for Red Hat OpenShift* from a local host using the **upgrade** command. Updating to the latest version ensures bug fixes and security vulnerability fixes.



IMPORTANT

When updating, there is intermittent downtime of your mirror registry, as it is restarted during the update process.

Prerequisites

- You have installed the *mirror registry for Red Hat OpenShift* on a local host.

Procedure

- To upgrade the *mirror registry for Red Hat OpenShift* from localhost, enter the following command:

```
$ sudo ./mirror-registry upgrade -v
```

NOTE

Users who upgrade the *mirror registry for Red Hat OpenShift* with the **./mirror-registry upgrade -v** flag must include the same credentials used when creating their mirror registry. For example, if you installed the *mirror registry for Red Hat OpenShift* with **--quayHostname <host_example_com>** and **--quayRoot <example_directory_name>**, you must include that string to properly upgrade the mirror registry.

- If you are upgrading the *mirror registry for Red Hat OpenShift* from 1.2.z → 1.3.0 and you used a specified directory in your 1.2.z deployment, you must pass in the new **--pgStorage** and **--quayStorage** flags. For example:

```
$ sudo ./mirror-registry upgrade --quayHostname <host_example_com> --quayRoot
<example_directory_name> --pgStorage <example_directory_name>/pg-data --quayStorage
<example_directory_name>/quay-storage -v
```

3.2.5. Mirroring on a remote host with mirror registry for Red Hat OpenShift

This procedure explains how to install the *mirror registry for Red Hat OpenShift* on a remote host using the **mirror-registry** tool. By doing so, users can create a registry to hold a mirror of OpenShift Container Platform images.

NOTE

Installing the *mirror registry for Red Hat OpenShift* using the **mirror-registry** CLI tool makes several changes to your machine. After installation, a **/etc/quay-install** directory is created, which has installation files, local storage, and the configuration bundle. Trusted SSH keys are generated in case the deployment target is the local host, and systemd files on the host machine are set up to ensure that container runtimes are persistent. Additionally, an initial user named **init** is created with an automatically generated password. All access credentials are printed at the end of the install routine.

Procedure

1. Download the **mirror-registry.tar.gz** package for the latest version of the *mirror registry for Red Hat OpenShift* found on the OpenShift console **Downloads** page.

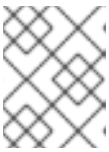
2. Install the *mirror registry for Red Hat OpenShift* on your local host with your current user account by using the **mirror-registry** tool. For a full list of available flags, see "mirror registry for Red Hat OpenShift flags".

```
$ ./mirror-registry install -v \
  --targetHostname <host_example_com> \
  --targetUsername <example_user> \
  -k ~/.ssh/my_ssh_key \
  --quayHostname <host_example_com> \
  --quayRoot <example_directory_name>
```

3. Use the user name and password generated during installation to log into the mirror registry by running the following command:

```
$ podman login -u init \
  -p <password> \
  <host_example_com>:8443> \
  --tls-verify=false 1
```

1 You can avoid running **--tls-verify=false** by configuring your system to trust the generated rootCA certificates. See "Using SSL to protect connections to Red Hat Quay" and "Configuring the system to trust the certificate authority" for more information.



NOTE

You can also log in by accessing the UI at **https://<host.example.com>:8443** after installation.

4. You can mirror OpenShift Container Platform images after logging in. Depending on your needs, see either the "Mirroring the OpenShift Container Platform image repository" or the "Mirroring Operator catalogs for use with disconnected clusters" sections of this document.

NOTE

If there are issues with images stored by the *mirror registry for Red Hat OpenShift* due to storage layer problems, you can remirror the OpenShift Container Platform images, or reinstall mirror registry on more stable storage.

3.2.6. Updating mirror registry for Red Hat OpenShift from a remote host

This procedure explains how to update the *mirror registry for Red Hat OpenShift* from a remote host using the **upgrade** command. Updating to the latest version ensures bug fixes and security vulnerability fixes.

IMPORTANT

When updating, there is intermittent downtime of your mirror registry, as it is restarted during the update process.

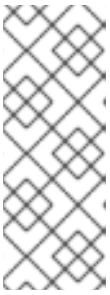
Prerequisites

- You have installed the *mirror registry for Red Hat OpenShift* on a remote host.

Procedure

- To upgrade the *mirror registry for Red Hat OpenShift* from a remote host, enter the following command:

```
$ ./mirror-registry upgrade -v --targetHostname <remote_host_url> --targetUsername
<user_name> -k ~/.ssh/my_ssh_key
```



NOTE

Users who upgrade the *mirror registry for Red Hat OpenShift* with the **./mirror-registry upgrade -v** flag must include the same credentials used when creating their mirror registry. For example, if you installed the *mirror registry for Red Hat OpenShift* with **--quayHostname <host_example_com>** and **--quayRoot <example_directory_name>**, you must include that string to properly upgrade the mirror registry.

3.2.7. Replacing mirror registry for Red Hat OpenShift SSL/TLS certificates

In some cases, you might want to update your SSL/TLS certificates for the *mirror registry for Red Hat OpenShift*. This is useful in the following scenarios:

- If you are replacing the current *mirror registry for Red Hat OpenShift* certificate.
- If you are using the same certificate as the previous *mirror registry for Red Hat OpenShift* installation.
- If you are periodically updating the *mirror registry for Red Hat OpenShift* certificate.

Use the following procedure to replace *mirror registry for Red Hat OpenShift* SSL/TLS certificates.

Prerequisites

- You have downloaded the **./mirror-registry** binary from the OpenShift console **Downloads** page.

Procedure

1. Enter the following command to install the *mirror registry for Red Hat OpenShift*:

```
$ ./mirror-registry install \
--quayHostname <host_example_com> \
--quayRoot <example_directory_name>
```

   This installs the *mirror registry for Red Hat OpenShift* to the **$HOME/quay-install** directory.

2. Prepare a new certificate authority (CA) bundle and generate new **ssl.key** and **ssl.crt** key files. For more information, see Using SSL/TLS.

3. Assign **/$HOME/quay-install** an environment variable, for example, **QUAY**, by entering the following command:

```
$ export QUAY=/$HOME/quay-install
```

4. Copy the new **ssl.crt** file to the **/$HOME/quay-install** directory by entering the following command:

```
$ cp ~/ssl.crt $QUAY/quay-config
```

5. Copy the new **ssl.key** file to the **/$HOME/quay-install** directory by entering the following command:

```
$ cp ~/ssl.key $QUAY/quay-config
```

6. Restart the **quay-app** application pod by entering the following command:

```
$ systemctl restart quay-app
```

3.2.8. Uninstalling the mirror registry for Red Hat OpenShift

- You can uninstall the *mirror registry for Red Hat OpenShift* from your local host by running the following command:

```
$ ./mirror-registry uninstall -v \
  --quayRoot <example_directory_name>
```

NOTE

- Deleting the *mirror registry for Red Hat OpenShift* will prompt the user before deletion. You can use **--autoApprove** to skip this prompt.
- Users who install the *mirror registry for Red Hat OpenShift* with the **--quayRoot** flag must include the **--quayRoot** flag when uninstalling. For example, if you installed the *mirror registry for Red Hat OpenShift* with **--quayRoot example_directory_name**, you must include that string to properly uninstall the mirror registry.

3.2.9. Mirror registry for Red Hat OpenShift flags

The following flags are available for the *mirror registry for Red Hat OpenShift*:

Flags	Description
--autoApprove	A boolean value that disables interactive prompts. If set to **true**, the **quayRoot** directory is automatically deleted when uninstalling the mirror registry. Defaults to **false** if left unspecified.
--initPassword	The password of the init user created during Quay installation. Must be at least eight characters and contain no whitespace.
--initUser string	Shows the username of the initial user. Defaults to **init** if left unspecified.
--no-color, **-c**	Allows users to disable color sequences and propagate that to Ansible when running install, uninstall, and upgrade commands.
--quayHostname	The fully-qualified domain name of the mirror registry that clients will use to contact the registry. Equivalent to **SERVER_HOSTNAME** in the Quay **config.yaml**. Must resolve by DNS. Defaults to**<targetHostname>:8443** if left unspecified. [1]
--quayRoot, **-r**	The directory where container image layer and configuration data is saved, including **rootCA.key**, **rootCA.pem**, and **rootCA.srl** certificates. Requires about 12 GB for OpenShift Container Platform 4.10 Release images, or about 358 GB for OpenShift Container Platform 4.10 Release images and OpenShift Container Platform 4.10 Red Hat Operator images. Defaults to **/etc/quay-install** if left unspecified.
--ssh-key, **-k**	The path of your SSH identity key. Defaults to **~/.ssh/quay_installer** if left unspecified.
--sslCert	The path to the SSL/TLS public key / certificate. Defaults to **{quayRoot}/quay-config** and is auto-generated if left unspecified.
--sslCheckSkip	Skips the check for the certificate hostname against the **SERVER_HOSTNAME** in the **config.yaml** file. [2]
--sslKey	The path to the SSL/TLS private key used for HTTPS communication. Defaults to **{quayRoot}/quay-config** and is auto-generated if left unspecified.
--targetHostname, **-H**	The hostname of the target you want to install Quay to. Defaults to **$HOST**, for example, a local host, if left unspecified.
--targetUsername, **-u**	The user on the target host which will be used for SSH. Defaults to **$USER**, for example, the current user if left unspecified.
--verbose, **-v**	Shows debug logs and Ansible playbook outputs.

1. **--quayHostname** must be modified if the public DNS name of your system is different from the local hostname. Additionally, the **--quayHostname** flag does not support installation with an IP address. Installation with a hostname is required.

2. **--sslCheckSkip** is used in cases when the mirror registry is set behind a proxy and the exposed hostname is different from the internal Quay hostname. It can also be used when users do not want the certificates to be validated against the provided Quay hostname during installation.

3.2.10. Mirror registry for Red Hat OpenShift release notes

The *mirror registry for Red Hat OpenShift* is a small and streamlined container registry that you can use as a target for mirroring the required container images of OpenShift Container Platform for disconnected installations.

These release notes track the development of the *mirror registry for Red Hat OpenShift* in OpenShift Container Platform.

For an overview of the *mirror registry for Red Hat OpenShift*, see Creating a mirror registry with mirror registry for Red Hat OpenShift.

3.2.10.1. Mirror registry for Red Hat OpenShift 1.3.10

Issued: 2023-12-07

Mirror registry for Red Hat OpenShift is now available with Red Hat Quay 3.8.14.

The following advisory is available for the *mirror registry for Red Hat OpenShift*:

- RHBA-2023:7628 - mirror registry for Red Hat OpenShift 1.3.10

3.2.10.2. Mirror registry for Red Hat OpenShift 1.3.9

Issued: 2023-09-19

Mirror registry for Red Hat OpenShift is now available with Red Hat Quay 3.8.12.

The following advisory is available for the *mirror registry for Red Hat OpenShift*:

- RHBA-2023:5241 - mirror registry for Red Hat OpenShift 1.3.9

3.2.10.3. Mirror registry for Red Hat OpenShift 1.3.8

Issued: 2023-08-16

Mirror registry for Red Hat OpenShift is now available with Red Hat Quay 3.8.11.

The following advisory is available for the *mirror registry for Red Hat OpenShift*:

- RHBA-2023:4622 - mirror registry for Red Hat OpenShift 1.3.8

3.2.10.4. Mirror registry for Red Hat OpenShift 1.3.7

Issued: 2023-07-19

Mirror registry for Red Hat OpenShift is now available with Red Hat Quay 3.8.10.

The following advisory is available for the *mirror registry for Red Hat OpenShift*:

- RHBA-2023:4087 - mirror registry for Red Hat OpenShift 1.3.7

3.2.10.5. Mirror registry for Red Hat OpenShift 1.3.6

Issued: 2023-05-30

Mirror registry for Red Hat OpenShift is now available with Red Hat Quay 3.8.8.

The following advisory is available for the *mirror registry for Red Hat OpenShift*:

- RHBA-2023:3302 - mirror registry for Red Hat OpenShift 1.3.6

3.2.10.6. Mirror registry for Red Hat OpenShift 1.3.5

Issued: 2023-05-18

Mirror registry for Red Hat OpenShift is now available with Red Hat Quay 3.8.7.

The following advisory is available for the *mirror registry for Red Hat OpenShift*:

- RHBA-2023:3225 - mirror registry for Red Hat OpenShift 1.3.5

3.2.10.7. Mirror registry for Red Hat OpenShift 1.3.4

Issued: 2023-04-25

Mirror registry for Red Hat OpenShift is now available with Red Hat Quay 3.8.6.

The following advisory is available for the *mirror registry for Red Hat OpenShift*:

- RHBA-2023:1914 - mirror registry for Red Hat OpenShift 1.3.4

3.2.10.8. Mirror registry for Red Hat OpenShift 1.3.3

Issued: 2023-04-05

Mirror registry for Red Hat OpenShift is now available with Red Hat Quay 3.8.5.

The following advisory is available for the *mirror registry for Red Hat OpenShift*:

- RHBA-2023:1528 - mirror registry for Red Hat OpenShift 1.3.3

3.2.10.9. Mirror registry for Red Hat OpenShift 1.3.2

Issued: 2023-03-21

Mirror registry for Red Hat OpenShift is now available with Red Hat Quay 3.8.4.

The following advisory is available for the *mirror registry for Red Hat OpenShift*:

- RHBA-2023:1376 - mirror registry for Red Hat OpenShift 1.3.2

3.2.10.10. Mirror registry for Red Hat OpenShift 1.3.1

Issued: 2023-03-7

Mirror registry for Red Hat OpenShift is now available with Red Hat Quay 3.8.3.

The following advisory is available for the *mirror registry for Red Hat OpenShift*:

- RHBA-2023:1086 - mirror registry for Red Hat OpenShift 1.3.1

3.2.10.11. Mirror registry for Red Hat OpenShift 1.3.0

Issued: 2023-02-20

Mirror registry for Red Hat OpenShift is now available with Red Hat Quay 3.8.1.

The following advisory is available for the *mirror registry for Red Hat OpenShift*:

- RHBA-2023:0558 - mirror registry for Red Hat OpenShift 1.3.0

3.2.10.11.1. New features

- *Mirror registry for Red Hat OpenShift* is now supported on Red Hat Enterprise Linux (RHEL) 9 installations.
- IPv6 support is now available on *mirror registry for Red Hat OpenShift* local host installations. IPv6 is currently unsupported on *mirror registry for Red Hat OpenShift* remote host installations.
- A new feature flag, **--quayStorage**, has been added. By specifying this flag, you can manually set the location for the Quay persistent storage.
- A new feature flag, **--pgStorage**, has been added. By specifying this flag, you can manually set the location for the Postgres persistent storage.
- Previously, users were required to have root privileges (**sudo**) to install *mirror registry for Red Hat OpenShift*. With this update, **sudo** is no longer required to install *mirror registry for Red Hat OpenShift*.
  When *mirror registry for Red Hat OpenShift* was installed with **sudo**, an **/etc/quay-install** directory that contained installation files, local storage, and the configuration bundle was created. With the removal of the **sudo** requirement, installation files and the configuration bundle are now installed to **$HOME/quay-install**. Local storage, for example Postgres and Quay, are now stored in named volumes automatically created by Podman.

  To override the default directories that these files are stored in, you can use the command line arguments for *mirror registry for Red Hat OpenShift*. For more information about *mirror registry for Red Hat OpenShift* command line arguments, see " *Mirror registry for Red Hat OpenShift* flags".

3.2.10.11.2. Bug fixes

- Previously, the following error could be returned when attempting to uninstall *mirror registry for Red Hat OpenShift*: **["Error: no container with name or ID \"quay-postgres\" found: no such container"], "stdout": "", "stdout_lines": []***. With this update, the order that *mirror registry for Red Hat OpenShift* services are stopped and uninstalled have been changed so that the error no longer occurs when uninstalling *mirror registry for Red Hat OpenShift*. For more information, see PROJQUAY-4629.

3.2.10.12. Mirror registry for Red Hat OpenShift 1.2.9

Mirror registry for Red Hat OpenShift is now available with Red Hat Quay 3.7.10.

The following advisory is available for the *mirror registry for Red Hat OpenShift*:

- RHBA-2022:7369 - mirror registry for Red Hat OpenShift 1.2.9

3.2.10.13. Mirror registry for Red Hat OpenShift 1.2.8

Mirror registry for Red Hat OpenShift is now available with Red Hat Quay 3.7.9.

The following advisory is available for the *mirror registry for Red Hat OpenShift*:

- RHBA-2022:7065 - mirror registry for Red Hat OpenShift 1.2.8

3.2.10.14. Mirror registry for Red Hat OpenShift 1.2.7

Mirror registry for Red Hat OpenShift is now available with Red Hat Quay 3.7.8.

The following advisory is available for the *mirror registry for Red Hat OpenShift*:

- RHBA-2022:6500 - mirror registry for Red Hat OpenShift 1.2.7

3.2.10.14.1. Bug fixes

- Previously, **getFQDN()** relied on the fully-qualified domain name (FQDN) library to determine its FQDN, and the FQDN library tried to read the **/etc/hosts** folder directly. Consequently, on some Red Hat Enterprise Linux CoreOS (RHCOS) installations with uncommon DNS configurations, the FQDN library would fail to install and abort the installation. With this update, *mirror registry for Red Hat OpenShift* uses **hostname** to determine the FQDN. As a result, the FQDN library does not fail to install. (**PROJQUAY-4139**)

3.2.10.15. Mirror registry for Red Hat OpenShift 1.2.6

Mirror registry for Red Hat OpenShift is now available with Red Hat Quay 3.7.7.

The following advisory is available for the *mirror registry for Red Hat OpenShift*:

- RHBA-2022:6278 - mirror registry for Red Hat OpenShift 1.2.6

3.2.10.15.1. New features

A new feature flag, **--no-color** (**-c**) has been added. This feature flag allows users to disable color sequences and propagate that to Ansible when running install, uninstall, and upgrade commands.

3.2.10.16. Mirror registry for Red Hat OpenShift 1.2.5

Mirror registry for Red Hat OpenShift is now available with Red Hat Quay 3.7.6.

The following advisory is available for the *mirror registry for Red Hat OpenShift*:

- RHBA-2022:6071 - mirror registry for Red Hat OpenShift 1.2.5

3.2.10.17. Mirror registry for Red Hat OpenShift 1.2.4

Mirror registry for Red Hat OpenShift is now available with Red Hat Quay 3.7.5.

The following advisory is available for the *mirror registry for Red Hat OpenShift*:

- RHBA-2022:5884 - mirror registry for Red Hat OpenShift 1.2.4

3.2.10.18. Mirror registry for Red Hat OpenShift 1.2.3

Mirror registry for Red Hat OpenShift is now available with Red Hat Quay 3.7.4.

The following advisory is available for the *mirror registry for Red Hat OpenShift*:

- RHBA-2022:5649 - mirror registry for Red Hat OpenShift 1.2.3

3.2.10.19. Mirror registry for Red Hat OpenShift 1.2.2

Mirror registry for Red Hat OpenShift is now available with Red Hat Quay 3.7.3.

The following advisory is available for the *mirror registry for Red Hat OpenShift*:

- RHBA-2022:5501 - mirror registry for Red Hat OpenShift 1.2.2

3.2.10.20. Mirror registry for Red Hat OpenShift 1.2.1

Mirror registry for Red Hat OpenShift is now available with Red Hat Quay 3.7.2.

The following advisory is available for the *mirror registry for Red Hat OpenShift*:

- RHBA-2022:4986 - mirror registry for Red Hat OpenShift 1.2.1

3.2.10.21. Mirror registry for Red Hat OpenShift 1.2.0

Mirror registry for Red Hat OpenShift is now available with Red Hat Quay 3.7.1.

The following advisory is available for the *mirror registry for Red Hat OpenShift*:

- RHBA-2022:4986 - mirror registry for Red Hat OpenShift 1.2.0

3.2.10.21.1. Bug fixes

- Previously, all components and workers running inside of the Quay pod Operator had log levels set to **DEBUG**. As a result, large traffic logs were created that consumed unnecessary space. With this update, log levels are set to **WARN** by default, which reduces traffic information while emphasizing problem scenarios. (**PROJQUAY-3504**)

3.2.10.22. Mirror registry for Red Hat OpenShift 1.1.0

The following advisory is available for the *mirror registry for Red Hat OpenShift*:

- RHBA-2022:0956 - mirror registry for Red Hat OpenShift 1.1.0

3.2.10.22.1. New features

- A new command, **mirror-registry upgrade** has been added. This command upgrades all container images without interfering with configurations or data.

NOTE

If **quayRoot** was previously set to something other than default, it must be passed into the upgrade command.

3.2.10.22.2. Bug fixes

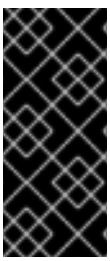
- Previously, the absence of **quayHostname** or **targetHostname** did not default to the local hostname. With this update, **quayHostname** and **targetHostname** now default to the local hostname if they are missing. (PROJQUAY-3079)
- Previously, the command **./mirror-registry --version** returned an **unknown flag** error. Now, running **./mirror-registry --version** returns the current version of the *mirror registry for Red Hat OpenShift*. (PROJQUAY-3086)
- Previously, users could not set a password during installation, for example, when running **./mirror-registry install --initUser <user_name> --initPassword <password> --verbose**. With this update, users can set a password during installation. (PROJQUAY-3149)
- Previously, the *mirror registry for Red Hat OpenShift* did not recreate pods if they were destroyed. Now, pods are recreated if they are destroyed. (PROJQUAY-3261)

3.2.11. Additional resources

- Red Hat Quay garbage collection
- Using SSL to protect connections to Red Hat Quay
- Configuring the system to trust the certificate authority
- Mirroring the OpenShift Container Platform image repository
- Mirroring Operator catalogs for use with disconnected clusters

3.3. MIRRORING IMAGES FOR A DISCONNECTED INSTALLATION

You can ensure your clusters only use container images that satisfy your organizational controls on external content. Before you install a cluster on infrastructure that you provision in a restricted network, you must mirror the required container images into that environment. To mirror container images, you must have a registry for mirroring.



IMPORTANT

You must have access to the internet to obtain the necessary container images. In this procedure, you place your mirror registry on a mirror host that has access to both your network and the internet. If you do not have access to a mirror host, use the Mirroring Operator catalogs for use with disconnected clusters procedure to copy images to a device you can move across network boundaries with.

3.3.1. Prerequisites

- You must have a container image registry that supports Docker v2-2 in the location that will host the OpenShift Container Platform cluster, such as one of the following registries:
  - Red Hat Quay

- JFrog Artifactory
- Sonatype Nexus Repository
- Harbor

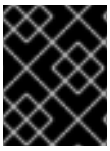
If you have an entitlement to Red Hat Quay, see the documentation on deploying Red Hat Quay for proof-of-concept purposes or by using the Red Hat Quay Operator. If you need additional assistance selecting and installing a registry, contact your sales representative or Red Hat support.

- If you do not already have an existing solution for a container image registry, subscribers of OpenShift Container Platform are provided a mirror registry for Red Hat OpenShift. The *mirror registry for Red Hat OpenShift* is included with your subscription and is a small-scale container registry that can be used to mirror the required container images of OpenShift Container Platform in disconnected installations.

3.3.2. About the mirror registry

You can mirror the images that are required for OpenShift Container Platform installation and subsequent product updates to a container mirror registry such as Red Hat Quay, JFrog Artifactory, Sonatype Nexus Repository, or Harbor. If you do not have access to a large-scale container registry, you can use the *mirror registry for Red Hat OpenShift*, a small-scale container registry included with OpenShift Container Platform subscriptions.

You can use any container registry that supports Docker v2-2, such as Red Hat Quay, the *mirror registry for Red Hat OpenShift*, Artifactory, Sonatype Nexus Repository, or Harbor. Regardless of your chosen registry, the procedure to mirror content from Red Hat hosted sites on the internet to an isolated image registry is the same. After you mirror the content, you configure each cluster to retrieve this content from your mirror registry.



IMPORTANT

The OpenShift image registry cannot be used as the target registry because it does not support pushing without a tag, which is required during the mirroring process.

If choosing a container registry that is not the *mirror registry for Red Hat OpenShift*, it must be reachable by every machine in the clusters that you provision. If the registry is unreachable, installation, updating, or normal operations such as workload relocation might fail. For that reason, you must run mirror registries in a highly available way, and the mirror registries must at least match the production availability of your OpenShift Container Platform clusters.

When you populate your mirror registry with OpenShift Container Platform images, you can follow two scenarios. If you have a host that can access both the internet and your mirror registry, but not your cluster nodes, you can directly mirror the content from that machine. This process is referred to as *connected mirroring*. If you have no such host, you must mirror the images to a file system and then bring that host or removable media into your restricted environment. This process is referred to as *disconnected mirroring*.

For mirrored registries, to view the source of pulled images, you must review the **Trying to access** log entry in the CRI-O logs. Other methods to view the image pull source, such as using the **crictl images** command on a node, show the non-mirrored image name, even though the image is pulled from the mirrored location.

NOTE

Red Hat does not test third party registries with OpenShift Container Platform.

Additional information

For information about viewing the CRI-O logs to view the image source, see Viewing the image pull source.

3.3.3. Preparing your mirror host

Before you perform the mirror procedure, you must prepare the host to retrieve content and push it to the remote location.

3.3.3.1. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.

IMPORTANT

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.11. Download and install the new version of **oc**.

Installing the OpenShift CLI on Linux
You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the architecture in the **Product Variant** drop-down menu.
3. Select the appropriate version in the **Version** drop-down menu.
4. Click **Download Now** next to the **OpenShift v4.11 Linux Client** entry and save the file.
5. Unpack the archive:

```
$ tar xvf <file>
```

6. Place the **oc** binary in a directory that is on your **PATH**.
   To check your **PATH**, execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.
   To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
C:\> oc <command>
```

Installing the OpenShift CLI on macOS

You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 macOS Client** entry and save the file.

NOTE

For macOS arm64, choose the **OpenShift v4.11 macOS arm64 Client** entry.

4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your PATH.
   To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

3.3.4. Configuring credentials that allow images to be mirrored

Create a container image registry credentials file that allows mirroring images from Red Hat to your mirror.

WARNING

Do not use this image registry credentials file as the pull secret when you install a cluster. If you provide this file when you install cluster, all of the machines in the cluster will have write access to your mirror registry.

WARNING

This process requires that you have write access to a container image registry on the mirror registry and adds the credentials to a registry pull secret.

Prerequisites

- You configured a mirror registry to use in your disconnected environment.
- You identified an image repository location on your mirror registry to mirror images into.
- You provisioned a mirror registry account that allows images to be uploaded to that image repository.

Procedure

Complete the following steps on the installation host:

1. Download your **registry.redhat.io** pull secret from the Red Hat OpenShift Cluster Manager .
2. Make a copy of your pull secret in JSON format:

```
$ cat ./pull-secret | jq . > <path>/<pull_secret_file_in_json> 1
```

1 Specify the path to the folder to store the pull secret in and a name for the JSON file that you create.

The contents of the file resemble the following example:

```
{
  "auths": {
    "cloud.openshift.com": {
      "auth": "b3BlbnNo...",
      "email": "you@example.com"
    },
```

```
    "quay.io": {
      "auth": "b3BlbnNo...",
      "email": "you@example.com"
    },
    "registry.connect.redhat.com": {
      "auth": "NTE3Njg5Nj...",
      "email": "you@example.com"
    },
    "registry.redhat.io": {
      "auth": "NTE3Njg5Nj...",
      "email": "you@example.com"
    }
  }
}
```

3. Generate the base64-encoded user name and password or token for your mirror registry:

```
$ echo -n '<user_name>:<password>' | base64 -w0 (1)
BGVtbYk3ZHAtqXs=
```

(1) For **<user_name>** and **<password>**, specify the user name and password that you configured for your registry.

4. Edit the JSON file and add a section that describes your registry to it:

```
"auths": {
  "<mirror_registry>": { (1)
    "auth": "<credentials>", (2)
    "email": "you@example.com"
  }
},
```

(1) For **<mirror_registry>**, specify the registry domain name, and optionally the port, that your mirror registry uses to serve content. For example, **registry.example.com** or **registry.example.com:8443**

(2) For **<credentials>**, specify the base64-encoded user name and password for the mirror registry.

The file resembles the following example:

```
{
  "auths": {
    "registry.example.com": {
      "auth": "BGVtbYk3ZHAtqXs=",
      "email": "you@example.com"
    },
    "cloud.openshift.com": {
      "auth": "b3BlbnNo...",
      "email": "you@example.com"
    },
    "quay.io": {
      "auth": "b3BlbnNo...",
```

```
    "email": "you@example.com"
  },
  "registry.connect.redhat.com": {
    "auth": "NTE3Njg5Nj...",
    "email": "you@example.com"
  },
  "registry.redhat.io": {
    "auth": "NTE3Njg5Nj...",
    "email": "you@example.com"
  }
 }
}
```

3.3.5. Mirroring the OpenShift Container Platform image repository

Mirror the OpenShift Container Platform image repository to your registry to use during cluster installation or upgrade.

Prerequisites

- Your mirror host has access to the internet.
- You configured a mirror registry to use in your restricted network and can access the certificate and credentials that you configured.
- You downloaded the pull secret from the Red Hat OpenShift Cluster Manager and modified it to include authentication to your mirror repository.
- If you use self-signed certificates, you have specified a Subject Alternative Name in the certificates.

Procedure

Complete the following steps on the mirror host:

1. Review the OpenShift Container Platform downloads page to determine the version of OpenShift Container Platform that you want to install and determine the corresponding tag on the Repository Tags page.
2. Set the required environment variables:
   a. Export the release version:

      ```
      $ OCP_RELEASE=<release_version>
      ```

      For **<release_version>**, specify the tag that corresponds to the version of OpenShift Container Platform to install, such as **4.5.4**.

   b. Export the local registry name and host port:

      ```
      $ LOCAL_REGISTRY='<local_registry_host_name>:<local_registry_host_port>'
      ```

      For **<local_registry_host_name>**, specify the registry domain name for your mirror repository, and for **<local_registry_host_port>**, specify the port that it serves content on.

   c. Export the local repository name:

```
$ LOCAL_REPOSITORY='<local_repository_name>'
```

For **<local_repository_name>**, specify the name of the repository to create in your registry, such as **ocp4/openshift4**.

d. Export the name of the repository to mirror:

```
$ PRODUCT_REPO='openshift-release-dev'
```

For a production release, you must specify **openshift-release-dev**.

e. Export the path to your registry pull secret:

```
$ LOCAL_SECRET_JSON='<path_to_pull_secret>'
```

For **<path_to_pull_secret>**, specify the absolute path to and file name of the pull secret for your mirror registry that you created.

f. Export the release mirror:

```
$ RELEASE_NAME="ocp-release"
```

For a production release, you must specify **ocp-release**.

g. Export the type of architecture for your server, such as **x86_64** or **aarch64**:

```
$ ARCHITECTURE=<server_architecture>
```

h. Export the path to the directory to host the mirrored images:

```
$ REMOVABLE_MEDIA_PATH=<path> 1
```

1 Specify the full path, including the initial forward slash (/) character.

3. Mirror the version images to the mirror registry:

- If your mirror host does not have internet access, take the following actions:

  i. Connect the removable media to a system that is connected to the internet.

  ii. Review the images and configuration manifests to mirror:

```
$ oc adm release mirror -a ${LOCAL_SECRET_JSON}  \
    --from=quay.io/${PRODUCT_REPO}/${RELEASE_NAME}:${OCP_RELEASE}-
${ARCHITECTURE} \
    --to=${LOCAL_REGISTRY}/${LOCAL_REPOSITORY} \
    --to-release-
image=${LOCAL_REGISTRY}/${LOCAL_REPOSITORY}:${OCP_RELEASE}-
${ARCHITECTURE} --dry-run
```

  iii. Record the entire **imageContentSources** section from the output of the previous command. The information about your mirrors is unique to your mirrored repository, and you must add the **imageContentSources** section to the **install-config.yaml** file during

installation.

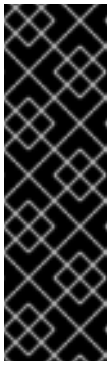
iv. Mirror the images to a directory on the removable media:

```
$ oc adm release mirror -a ${LOCAL_SECRET_JSON} --to-
dir=${REMOVABLE_MEDIA_PATH}/mirror
quay.io/${PRODUCT_REPO}/${RELEASE_NAME}:${OCP_RELEASE}-
${ARCHITECTURE}
```

v. Take the media to the restricted network environment and upload the images to the local container registry.

```
$ oc image mirror -a ${LOCAL_SECRET_JSON} --from-
dir=${REMOVABLE_MEDIA_PATH}/mirror
"file://openshift/release:${OCP_RELEASE}*"
${LOCAL_REGISTRY}/${LOCAL_REPOSITORY} 1
```

1 For **REMOVABLE_MEDIA_PATH**, you must use the same path that you specified when you mirrored the images.



IMPORTANT

Running **oc image mirror** might result in the following error: **error: unable to retrieve source image**. This error occurs when image indexes include references to images that no longer exist on the image registry. Image indexes might retain older references to allow users running those images an upgrade path to newer points on the upgrade graph. As a temporary workaround, you can use the **--skip-missing** option to bypass the error and continue downloading the image index. For more information, see Service Mesh Operator mirroring failed.

- If the local container registry is connected to the mirror host, take the following actions:

  i. Directly push the release images to the local registry by using following command:

```
$ oc adm release mirror -a ${LOCAL_SECRET_JSON}  \
    --from=quay.io/${PRODUCT_REPO}/${RELEASE_NAME}:${OCP_RELEASE}-
${ARCHITECTURE} \
    --to=${LOCAL_REGISTRY}/${LOCAL_REPOSITORY} \
    --to-release-
image=${LOCAL_REGISTRY}/${LOCAL_REPOSITORY}:${OCP_RELEASE}-
${ARCHITECTURE}
```

  This command pulls the release information as a digest, and its output includes the **imageContentSources** data that you require when you install your cluster.

  ii. Record the entire **imageContentSources** section from the output of the previous command. The information about your mirrors is unique to your mirrored repository, and you must add the **imageContentSources** section to the **install-config.yaml** file during installation.

NOTE

The image name gets patched to Quay.io during the mirroring process, and the podman images will show Quay.io in the registry on the bootstrap virtual machine.

4. To create the installation program that is based on the content that you mirrored, extract it and pin it to the release:

   - If your mirror host does not have internet access, run the following command:

     ```
     $ oc adm release extract -a ${LOCAL_SECRET_JSON} --icsp-file=<file> \ --
     command=openshift-install
     "${LOCAL_REGISTRY}/${LOCAL_REPOSITORY}:${OCP_RELEASE}"
     ```

   - If the local container registry is connected to the mirror host, run the following command:

     ```
     $ oc adm release extract -a ${LOCAL_SECRET_JSON} --command=openshift-install
     "${LOCAL_REGISTRY}/${LOCAL_REPOSITORY}:${OCP_RELEASE}-
     ${ARCHITECTURE}"
     ```

IMPORTANT

To ensure that you use the correct images for the version of OpenShift Container Platform that you selected, you must extract the installation program from the mirrored content.

You must perform this step on a machine with an active internet connection.

5. For clusters using installer-provisioned infrastructure, run the following command:

   ```
   $ openshift-install
   ```

3.3.6. The Cluster Samples Operator in a disconnected environment

In a disconnected environment, you must take additional steps after you install a cluster to configure the Cluster Samples Operator. Review the following information in preparation.

3.3.6.1. Cluster Samples Operator assistance for mirroring

During installation, OpenShift Container Platform creates a config map named **imagestreamtag-to-image** in the **openshift-cluster-samples-operator** namespace. The **imagestreamtag-to-image** config map contains an entry, the populating image, for each image stream tag.

The format of the key for each entry in the data field in the config map is **<image_stream_name>_<image_stream_tag_name>**.

During a disconnected installation of OpenShift Container Platform, the status of the Cluster Samples Operator is set to **Removed**. If you choose to change it to **Managed**, it installs samples.

NOTE

The use of samples in a network-restricted or discontinued environment may require access to services external to your network. Some example services include: Github, Maven Central, npm, RubyGems, PyPi and others. There might be additional steps to take that allow the cluster samples operators's objects to reach the services they require.

You can use this config map as a reference for which images need to be mirrored for your image streams to import.

- While the Cluster Samples Operator is set to **Removed**, you can create your mirrored registry, or determine which existing mirrored registry you want to use.
- Mirror the samples you want to the mirrored registry using the new config map as your guide.
- Add any of the image streams you did not mirror to the **skippedImagestreams** list of the Cluster Samples Operator configuration object.
- Set **samplesRegistry** of the Cluster Samples Operator configuration object to the mirrored registry.
- Then set the Cluster Samples Operator to **Managed** to install the image streams you have mirrored.

3.3.7. Mirroring Operator catalogs for use with disconnected clusters

You can mirror the Operator contents of a Red Hat-provided catalog, or a custom catalog, into a container image registry using the **oc adm catalog mirror** command. The target registry must support Docker v2-2. For a cluster on a restricted network, this registry can be one that the cluster has network access to, such as a mirror registry created during a restricted network cluster installation.

IMPORTANT

- The OpenShift image registry cannot be used as the target registry because it does not support pushing without a tag, which is required during the mirroring process.
- Running **oc adm catalog mirror** might result in the following error: **error: unable to retrieve source image**. This error occurs when image indexes include references to images that no longer exist on the image registry. Image indexes might retain older references to allow users running those images an upgrade path to newer points on the upgrade graph. As a temporary workaround, you can use the **--skip-missing** option to bypass the error and continue downloading the image index. For more information, see Service Mesh Operator mirroring failed.

The **oc adm catalog mirror** command also automatically mirrors the index image that is specified during the mirroring process, whether it be a Red Hat-provided index image or your own custom-built index image, to the target registry. You can then use the mirrored index image to create a catalog source that allows Operator Lifecycle Manager (OLM) to load the mirrored catalog onto your OpenShift Container Platform cluster.

Additional resources

- Using Operator Lifecycle Manager on restricted networks

3.3.7.1. Prerequisites

Mirroring Operator catalogs for use with disconnected clusters has the following prerequisites:

- Workstation with unrestricted network access.
- **podman** version 1.9.3 or later.
- If you want to filter, or *prune*, an existing catalog and selectively mirror only a subset of Operators, see the following sections:
  - Installing the opm CLI
  - Updating or filtering a file-based catalog image
- If you want to mirror a Red Hat-provided catalog, run the following command on your workstation with unrestricted network access to authenticate with **registry.redhat.io**:

```
$ podman login registry.redhat.io
```

- Access to a mirror registry that supports Docker v2-2.
- On your mirror registry, decide which repository, or namespace, to use for storing mirrored Operator content. For example, you might create an **olm-mirror** repository.
- If your mirror registry does not have internet access, connect removable media to your workstation with unrestricted network access.
- If you are working with private registries, including **registry.redhat.io**, set the **REG_CREDS** environment variable to the file path of your registry credentials for use in later steps. For example, for the **podman** CLI:

```
$ REG_CREDS=${XDG_RUNTIME_DIR}/containers/auth.json
```

3.3.7.2. Extracting and mirroring catalog contents

The **oc adm catalog mirror** command extracts the contents of an index image to generate the manifests required for mirroring. The default behavior of the command generates manifests, then automatically mirrors all of the image content from the index image, as well as the index image itself, to your mirror registry.

Alternatively, if your mirror registry is on a completely disconnected, or *airgapped*, host, you can first mirror the content to removable media, move the media to the disconnected environment, then mirror the content from the media to the registry.

3.3.7.2.1. Mirroring catalog contents to registries on the same network

If your mirror registry is co-located on the same network as your workstation with unrestricted network access, take the following actions on your workstation.

Procedure

1. If your mirror registry requires authentication, run the following command to log in to the registry:

```
$ podman login <mirror_registry>
```

2. Run the following command to extract and mirror the content to the mirror registry:

```
$ oc adm catalog mirror \
    <index_image> \ 1
    <mirror_registry>:<port>[/<repository>] \ 2
    [-a ${REG_CREDS}] \ 3
    [--insecure] \ 4
    [--index-filter-by-os='<platform>/<arch>'] \ 5
    [--manifests-only] 6
```

1. Specify the index image for the catalog that you want to mirror.

2. Specify the fully qualified domain name (FQDN) for the target registry to mirror the Operator contents to. The mirror registry **<repository>** can be any existing repository, or namespace, on the registry, for example **olm-mirror** as outlined in the prerequisites. If there is an existing repository found during mirroring, the repository name is added to the resulting image name. If you do not want the image name to include the repository name, omit the **<repository>** value from this line, for example **<mirror_registry>:<port>**.

3. Optional: If required, specify the location of your registry credentials file. **{REG_CREDS}** is required for **registry.redhat.io**.

4. Optional: If you do not want to configure trust for the target registry, add the **--insecure** flag.

5. Optional: Specify which platform and architecture of the index image to select when multiple variants are available. Images are passed as **'<platform>/<arch>[/<variant>]'**. This does not apply to images referenced by the index. Valid values are **linux/amd64**, **linux/ppc64le**, **linux/s390x**, **linux/arm64**.

6. Optional: Generate only the manifests required for mirroring without actually mirroring the image content to a registry. This option can be useful for reviewing what will be mirrored, and lets you make any changes to the mapping list, if you require only a subset of packages. You can then use the **mapping.txt** file with the **oc image mirror** command to mirror the modified list of images in a later step. This flag is intended for only advanced selective mirroring of content from the catalog.

Example output

```
src image has index label for database path: /database/index.db
using database path mapping: /database/index.db:/tmp/153048078
wrote database to /tmp/153048078 1
...
wrote mirroring manifests to manifests-redhat-operator-index-1614211642 2
```

1. Directory for the temporary **index.db** database generated by the command.

2. Record the manifests directory name that is generated. This directory is referenced in subsequent procedures.

NOTE

Red Hat Quay does not support nested repositories. As a result, running the **oc adm catalog mirror** command will fail with a **401** unauthorized error. As a workaround, you can use the **--max-components=2** option when running the **oc adm catalog mirror** command to disable the creation of nested repositories. For more information on this workaround, see the Unauthorized error thrown while using catalog mirror command with Quay registry Knowledgebase Solution.

Additional resources

- Architecture and operating system support for Operators

3.3.7.2.2. Mirroring catalog contents to airgapped registries

If your mirror registry is on a completely disconnected, or airgapped, host, take the following actions.

Procedure

1. Run the following command on your workstation with unrestricted network access to mirror the content to local files:

```
$ oc adm catalog mirror \
    <index_image> \ 1
    file:///local/index \ 2
    -a ${REG_CREDS} \ 3
    --insecure \ 4
    --index-filter-by-os='<platform>/<arch>' 5
```

1. Specify the index image for the catalog that you want to mirror.
2. Specify the content to mirror to local files in your current directory.
3. Optional: If required, specify the location of your registry credentials file.
4. Optional: If you do not want to configure trust for the target registry, add the **--insecure** flag.
5. Optional: Specify which platform and architecture of the index image to select when multiple variants are available. Images are specified as **'<platform>/<arch>[/<variant>]'**. This does not apply to images referenced by the index. Valid values are **linux/amd64**, **linux/ppc64le**, **linux/s390x**, **linux/arm64**, and **.***

Example output

```
...
info: Mirroring completed in 5.93s (5.915MB/s)
wrote mirroring manifests to manifests-my-index-1614985528 1

To upload local images to a registry, run:

 oc adm catalog mirror file://local/index/myrepo/my-index:v1 REGISTRY/REPOSITORY 2
```

1. Record the manifests directory name that is generated. This directory is referenced in subsequent procedures.
2. Record the expanded **file:**// path that is based on your provided index image. This path is referenced in a subsequent step.

This command creates a **v2**/ directory in your current directory.

2. Copy the **v2**/ directory to removable media.
3. Physically remove the media and attach it to a host in the disconnected environment that has access to the mirror registry.
4. If your mirror registry requires authentication, run the following command on your host in the disconnected environment to log in to the registry:

```
$ podman login <mirror_registry>
```

5. Run the following command from the parent directory containing the **v2**/ directory to upload the images from local files to the mirror registry:

```
$ oc adm catalog mirror \
    file://local/index/<repository>/<index_image>:<tag> \ 1
    <mirror_registry>:<port>[/<repository>] \ 2
    -a ${REG_CREDS} \ 3
    --insecure \ 4
    --index-filter-by-os='<platform>/<arch>' 5
```

1. Specify the **file:**// path from the previous command output.
2. Specify the fully qualified domain name (FQDN) for the target registry to mirror the Operator contents to. The mirror registry **<repository>** can be any existing repository, or namespace, on the registry, for example **olm-mirror** as outlined in the prerequisites. If there is an existing repository found during mirroring, the repository name is added to the resulting image name. If you do not want the image name to include the repository name, omit the **<repository>** value from this line, for example **<mirror_registry>:<port>**.
3. Optional: If required, specify the location of your registry credentials file.
4. Optional: If you do not want to configure trust for the target registry, add the **--insecure** flag.
5. Optional: Specify which platform and architecture of the index image to select when multiple variants are available. Images are specified as **'<platform>/<arch>[/<variant>]'**. This does not apply to images referenced by the index. Valid values are **linux/amd64**, **linux/ppc64le**, **linux/s390x**, **linux/arm64**, and **.***

NOTE

Red Hat Quay does not support nested repositories. As a result, running the **oc adm catalog mirror** command will fail with a **401** unauthorized error. As a workaround, you can use the **--max-components=2** option when running the **oc adm catalog mirror** command to disable the creation of nested repositories. For more information on this workaround, see the Unauthorized error thrown while using catalog mirror command with Quay registry Knowledgebase Solution.

6. Run the **oc adm catalog mirror** command again. Use the newly mirrored index image as the source and the same mirror registry target used in the previous step:

```
$ oc adm catalog mirror \
    <mirror_registry>:<port>/<index_image> \
    <mirror_registry>:<port>[/<repository>] \
    --manifests-only \ 1
    [-a ${REG_CREDS}] \
    [--insecure]
```

1 The **--manifests-only** flag is required for this step so that the command does not copy all of the mirrored content again.

IMPORTANT

This step is required because the image mappings in the **imageContentSourcePolicy.yaml** file generated during the previous step must be updated from local paths to valid mirror locations. Failure to do so will cause errors when you create the **ImageContentSourcePolicy** object in a later step.

After you mirror the catalog, you can continue with the remainder of your cluster installation. After your cluster installation has finished successfully, you must specify the manifests directory from this procedure to create the **ImageContentSourcePolicy** and **CatalogSource** objects. These objects are required to enable installation of Operators from OperatorHub.

Additional resources

- Architecture and operating system support for Operators

3.3.7.3. Generated manifests

After mirroring Operator catalog content to your mirror registry, a manifests directory is generated in your current directory.

If you mirrored content to a registry on the same network, the directory name takes the following pattern:

```
manifests-<index_image_name>-<random_number>
```

If you mirrored content to a registry on a disconnected host in the previous section, the directory name takes the following pattern:

```
manifests-index/<repository>/<index_image_name>-<random_number>
```

NOTE

The manifests directory name is referenced in subsequent procedures.

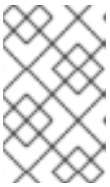
The manifests directory contains the following files, some of which might require further modification:

- The **catalogSource.yaml** file is a basic definition for a **CatalogSource** object that is pre-populated with your index image tag and other relevant metadata. This file can be used as is or modified to add the catalog source to your cluster.

IMPORTANT

If you mirrored the content to local files, you must modify your **catalogSource.yaml** file to remove any backslash (/) characters from the **metadata.name** field. Otherwise, when you attempt to create the object, it fails with an "invalid resource name" error.

- The **imageContentSourcePolicy.yaml** file defines an **ImageContentSourcePolicy** object that can configure nodes to translate between the image references stored in Operator manifests and the mirrored registry.



NOTE

If your cluster uses an **ImageContentSourcePolicy** object to configure repository mirroring, you can use only global pull secrets for mirrored registries. You cannot add a pull secret to a project.

- The **mapping.txt** file contains all of the source images and where to map them in the target registry. This file is compatible with the **oc image mirror** command and can be used to further customize the mirroring configuration.

IMPORTANT

If you used the **--manifests-only** flag during the mirroring process and want to further trim the subset of packages to mirror, see the steps in the Mirroring a package manifest format catalog image procedure of the OpenShift Container Platform 4.7 documentation about modifying your **mapping.txt** file and using the file with the **oc image mirror** command.

3.3.7.4. Postinstallation requirements

After you mirror the catalog, you can continue with the remainder of your cluster installation. After your cluster installation has finished successfully, you must specify the manifests directory from this procedure to create the **ImageContentSourcePolicy** and **CatalogSource** objects. These objects are required to populate and enable installation of Operators from OperatorHub.

Additional resources

- Populating OperatorHub from mirrored Operator catalogs
- Updating or filtering a file-based catalog image

3.3.8. Next steps

- Install a cluster on infrastructure that you provision in your restricted network, such as on VMware vSphere, bare metal, or Amazon Web Services.

3.3.9. Additional resources

- See Gathering data about specific features for more information about using must-gather.

3.4. MIRRORING IMAGES FOR A DISCONNECTED INSTALLATION USING THE OC-MIRROR PLUGIN

Running your cluster in a restricted network without direct internet connectivity is possible by installing the cluster from a mirrored set of OpenShift Container Platform container images in a private registry. This registry must be running at all times as long as the cluster is running. See the Prerequisites section for more information.

You can use the oc-mirror OpenShift CLI (**oc**) plugin to mirror images to a mirror registry in your fully or partially disconnected environments. You must run oc-mirror from a system with internet connectivity in order to download the required images from the official Red Hat registries.

The following steps outline the high-level workflow on how to use the oc-mirror plugin to mirror images to a mirror registry:

1. Create an image set configuration file.
2. Mirror the image set to the mirror registry by using one of the following methods:
   - Mirror an image set directly to the mirror registry.
   - Mirror an image set to disk, transfer the image set to the target environment, then upload the image set to the target mirror registry.
3. Configure your cluster to use the resources generated by the oc-mirror plugin.
4. Repeat these steps to update your mirror registry as necessary.

3.4.1. About the oc-mirror plugin

You can use the oc-mirror OpenShift CLI (**oc**) plugin to mirror all required OpenShift Container Platform content and other images to your mirror registry by using a single tool. It provides the following features:

- Provides a centralized method to mirror OpenShift Container Platform releases, Operators, helm charts, and other images.
- Maintains update paths for OpenShift Container Platform and Operators.
- Uses a declarative image set configuration file to include only the OpenShift Container Platform releases, Operators, and images that your cluster needs.
- Performs incremental mirroring, which reduces the size of future image sets.
- Prunes images from the target mirror registry that were excluded from the image set configuration since the previous execution.
- Optionally generates supporting artifacts for OpenShift Update Service (OSUS) usage.

When using the oc-mirror plugin, you specify which content to mirror in an image set configuration file. In this YAML file, you can fine-tune the configuration to only include the OpenShift Container Platform releases and Operators that your cluster needs. This reduces the amount of data that you need to download and transfer. The oc-mirror plugin can also mirror arbitrary helm charts and additional container images to assist users in seamlessly synchronizing their workloads onto mirror registries.

The first time you run the oc-mirror plugin, it populates your mirror registry with the required content to perform your disconnected cluster installation or update. In order for your disconnected cluster to continue receiving updates, you must keep your mirror registry updated. To update your mirror registry, you run the oc-mirror plugin using the same configuration as the first time you ran it. The oc-mirror plugin references the metadata from the storage backend and only downloads what has been released since the last time you ran the tool. This provides update paths for OpenShift Container Platform and Operators and performs dependency resolution as required.

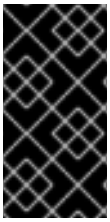
IMPORTANT

When using the oc-mirror CLI plugin to populate a mirror registry, any further updates to the mirror registry must be made using the oc-mirror tool.

3.4.2. oc-mirror compatibility and support

The oc-mirror plugin supports mirroring OpenShift Container Platform payload images and Operator catalogs for OpenShift Container Platform versions 4.9 and later.

Use the latest available version of the oc-mirror plugin regardless of which versions of OpenShift Container Platform you need to mirror.



IMPORTANT

If you used the Technology Preview version of the oc-mirror plugin for OpenShift Container Platform 4.10, it is not possible to migrate your mirror registry to OpenShift Container Platform 4.11. You must download the new oc-mirror plugin, use a new storage back end, and use a new top-level namespace on the target mirror registry.

3.4.3. About the mirror registry

You can mirror the images that are required for OpenShift Container Platform installation and subsequent product updates to a container mirror registry that supports Docker v2-2, such as Red Hat Quay. If you do not have access to a large-scale container registry, you can use the *mirror registry for Red Hat OpenShift*, which is a small-scale container registry included with OpenShift Container Platform subscriptions.

Regardless of your chosen registry, the procedure to mirror content from Red Hat hosted sites on the internet to an isolated image registry is the same. After you mirror the content, you configure each cluster to retrieve this content from your mirror registry.

IMPORTANT

The OpenShift image registry cannot be used as the target registry because it does not support pushing without a tag, which is required during the mirroring process.

If choosing a container registry that is not the *mirror registry for Red Hat OpenShift* , it must be reachable by every machine in the clusters that you provision. If the registry is unreachable, installation, updating, or normal operations such as workload relocation might fail. For that reason, you must run mirror

registries in a highly available way, and the mirror registries must at least match the production availability of your OpenShift Container Platform clusters.

When you populate your mirror registry with OpenShift Container Platform images, you can follow two scenarios. If you have a host that can access both the internet and your mirror registry, but not your cluster nodes, you can directly mirror the content from that machine. This process is referred to as *connected mirroring*. If you have no such host, you must mirror the images to a file system and then bring that host or removable media into your restricted environment. This process is referred to as *disconnected mirroring*.

For mirrored registries, to view the source of pulled images, you must review the **Trying to access** log entry in the CRI-O logs. Other methods to view the image pull source, such as using the **crictl images** command on a node, show the non-mirrored image name, even though the image is pulled from the mirrored location.

NOTE

Red Hat does not test third party registries with OpenShift Container Platform.

Additional resources

- For information about viewing the CRI-O logs to view the image source, see Viewing the image pull source.

3.4.4. Prerequisites

- You must have a container image registry that supports Docker v2-2 in the location that will host the OpenShift Container Platform cluster, such as Red Hat Quay.

NOTE

If you use Red Hat Quay, you must use version 3.6 or later with the oc-mirror plugin. If you have an entitlement to Red Hat Quay, see the documentation on deploying Red Hat Quay for proof-of-concept purposes or by using the Red Hat Quay Operator. If you need additional assistance selecting and installing a registry, contact your sales representative or Red Hat Support.

If you do not already have an existing solution for a container image registry, subscribers of OpenShift Container Platform are provided a mirror registry for Red Hat OpenShift . The *mirror registry for Red Hat OpenShift* is included with your subscription and is a small-scale container registry that can be used to mirror the required container images of OpenShift Container Platform in disconnected installations.

3.4.5. Preparing your mirror hosts

Before you can use the oc-mirror plugin to mirror images, you must install the plugin and create a container image registry credentials file to allow the mirroring from Red Hat to your mirror.

3.4.5.1. Installing the oc-mirror OpenShift CLI plugin

To use the oc-mirror OpenShift CLI plugin to mirror registry images, you must install the plugin. If you are mirroring image sets in a fully disconnected environment, ensure that you install the oc-mirror plugin on the host with internet access and the host in the disconnected environment with access to the mirror registry.

Prerequisites

- You have installed the OpenShift CLI (**oc**).

Procedure

1. Download the oc-mirror CLI plugin.
   a. Navigate to the Downloads page of the OpenShift Cluster Manager Hybrid Cloud Console .
   b. Under the **OpenShift disconnected installation tools** section, click **Download** for **OpenShift Client (oc) mirror plugin** and save the file.
2. Extract the archive:

```
$ tar xvzf oc-mirror.tar.gz
```

3. If necessary, update the plugin file to be executable:

```
$ chmod +x oc-mirror
```

NOTE

Do not rename the **oc-mirror** file.

4. Install the oc-mirror CLI plugin by placing the file in your **PATH**, for example, **/usr/local/bin**:

```
$ sudo mv oc-mirror /usr/local/bin/.
```

Verification

- Run **oc mirror help** to verify that the plugin was successfully installed:

```
$ oc mirror help
```

Additional resources

- Installing and using CLI plugins

3.4.5.2. Configuring credentials that allow images to be mirrored

Create a container image registry credentials file that allows mirroring images from Red Hat to your mirror.

WARNING

Do not use this image registry credentials file as the pull secret when you install a cluster. If you provide this file when you install cluster, all of the machines in the cluster will have write access to your mirror registry.

WARNING

This process requires that you have write access to a container image registry on the mirror registry and adds the credentials to a registry pull secret.

Prerequisites

- You configured a mirror registry to use in your disconnected environment.
- You identified an image repository location on your mirror registry to mirror images into.
- You provisioned a mirror registry account that allows images to be uploaded to that image repository.

Procedure

Complete the following steps on the installation host:

1. Download your **registry.redhat.io** pull secret from the Red Hat OpenShift Cluster Manager .
2. Make a copy of your pull secret in JSON format:

```
$ cat ./pull-secret | jq . > <path>/<pull_secret_file_in_json> 1
```

1 Specify the path to the folder to store the pull secret in and a name for the JSON file that you create.

The contents of the file resemble the following example:

```
{
  "auths": {
    "cloud.openshift.com": {
      "auth": "b3BlbnNo...",
      "email": "you@example.com"
    },
    "quay.io": {
      "auth": "b3BlbnNo...",
      "email": "you@example.com"
    },
    "registry.connect.redhat.com": {
```

```
    "auth": "NTE3Njg5Nj...",
    "email": "you@example.com"
  },
  "registry.redhat.io": {
    "auth": "NTE3Njg5Nj...",
    "email": "you@example.com"
  }
 }
}
```

3. Save the file either as ~/**.docker/config.json** or **$XDG_RUNTIME_DIR/containers/auth.json**.

4. Generate the base64-encoded user name and password or token for your mirror registry:

```
$ echo -n '<user_name>:<password>' | base64 -w0 (1)
BGVtbYk3ZHAtqXs=
```

(1) For **<user_name>** and **<password>**, specify the user name and password that you configured for your registry.

5. Edit the JSON file and add a section that describes your registry to it:

```
"auths": {
  "<mirror_registry>": { (1)
    "auth": "<credentials>", (2)
    "email": "you@example.com"
  }
},
```

(1) For **<mirror_registry>**, specify the registry domain name, and optionally the port, that your mirror registry uses to serve content. For example, **registry.example.com** or **registry.example.com:8443**

(2) For **<credentials>**, specify the base64-encoded user name and password for the mirror registry.

The file resembles the following example:

```
{
 "auths": {
  "registry.example.com": {
    "auth": "BGVtbYk3ZHAtqXs=",
    "email": "you@example.com"
  },
  "cloud.openshift.com": {
    "auth": "b3BlbnNo...",
    "email": "you@example.com"
  },
  "quay.io": {
    "auth": "b3BlbnNo...",
    "email": "you@example.com"
  },
  "registry.connect.redhat.com": {
```

```
      "auth": "NTE3Njg5Nj...",
      "email": "you@example.com"
    },
    "registry.redhat.io": {
      "auth": "NTE3Njg5Nj...",
      "email": "you@example.com"
    }
  }
}
```

3.4.6. Creating the image set configuration

Before you can use the oc-mirror plugin to mirror image sets, you must create an image set configuration file. This image set configuration file defines which OpenShift Container Platform releases, Operators, and other images to mirror, along with other configuration settings for the oc-mirror plugin.

You must specify a storage backend in the image set configuration file. This storage backend can be a local directory or a registry that supports Docker v2-2. The oc-mirror plugin stores metadata in this storage backend during image set creation.

IMPORTANT

Do not delete or modify the metadata that is generated by the oc-mirror plugin. You must use the same storage backend every time you run the oc-mirror plugin for the same mirror registry.

Prerequisites

- You have created a container image registry credentials file. For instructions, see *Configuring credentials that allow images to be mirrored*.

Procedure

1. Use the **oc mirror init** command to create a template for the image set configuration and save it to a file called **imageset-config.yaml**:

```
$ oc mirror init --registry example.com/mirror/oc-mirror-metadata > imageset-config.yaml 1
```

1 Replace **example.com/mirror/oc-mirror-metadata** with the location of your registry for the storage backend.

2. Edit the file and adjust the settings as necessary:

```
kind: ImageSetConfiguration
apiVersion: mirror.openshift.io/v1alpha2
archiveSize: 4                                          1
storageConfig:                                          2
  registry:
    imageURL: example.com/mirror/oc-mirror-metadata     3
    skipTLS: false
mirror:
  platform:
```

```
  channels:
  - name: stable-4.11                                    4
    type: ocp
  graph: true                                            5
operators:
- catalog: registry.redhat.io/redhat/redhat-operator-index:v4.11   6
  packages:
  - name: serverless-operator                            7
    channels:
    - name: stable                                       8
additionalImages:
- name: registry.redhat.io/ubi8/ubi:latest               9
helm: {}
```

1. Add **archiveSize** to set the maximum size, in GiB, of each file within the image set.
2. Set the back-end location to save the image set metadata to. This location can be a registry or local directory. It is required to specify **storageConfig** values.
3. Set the registry URL for the storage backend.
4. Set the channel to retrieve the OpenShift Container Platform images from.
5. Add **graph: true** to build and push the graph-data image to the mirror registry. The graph-data image is required to create OpenShift Update Service (OSUS). The **graph: true** field also generates the **UpdateService** custom resource manifest. The **oc** command-line interface (CLI) can use the **UpdateService** custom resource manifest to create OSUS. For more information, see *About the OpenShift Update Service* .
6. Set the Operator catalog to retrieve the OpenShift Container Platform images from.
7. Specify only certain Operator packages to include in the image set. Remove this field to retrieve all packages in the catalog.
8. Specify only certain channels of the Operator packages to include in the image set. You must always include the default channel for the Operator package even if you do not use the bundles in that channel. You can find the default channel by running the following command: **oc mirror list operators --catalog=<catalog_name> --package=<package_name>**.
9. Specify any additional images to include in image set.

See *Image set configuration parameters* for the full list of parameters and *Image set configuration examples* for various mirroring use cases.

3. Save the updated file.
   This image set configuration file is required by the **oc mirror** command when mirroring content.

Additional resources

- Image set configuration parameters
- Image set configuration examples
- Using the OpenShift Update Service in a disconnected environment

3.4.7. Mirroring an image set to a mirror registry

You can use the oc-mirror CLI plugin to mirror images to a mirror registry in a partially disconnected environment or in a fully disconnected environment.

These procedures assume that you already have your mirror registry set up.

3.4.7.1. Mirroring an image set in a partially disconnected environment

In a partially disconnected environment, you can mirror an image set directly to the target mirror registry.

3.4.7.1.1. Mirroring from mirror to mirror

You can use the oc-mirror plugin to mirror an image set directly to a target mirror registry that is accessible during image set creation.

You are required to specify a storage backend in the image set configuration file. This storage backend can be a local directory or a Docker v2 registry. The oc-mirror plugin stores metadata in this storage backend during image set creation.

IMPORTANT

Do not delete or modify the metadata that is generated by the oc-mirror plugin. You must use the same storage backend every time you run the oc-mirror plugin for the same mirror registry.

Prerequisites

- You have access to the internet to obtain the necessary container images.
- You have installed the OpenShift CLI (**oc**).
- You have installed the **oc-mirror** CLI plugin.
- You have created the image set configuration file.

Procedure

- Run the **oc mirror** command to mirror the images from the specified image set configuration to a specified registry:

```
$ oc mirror --config=./imageset-config.yaml \ 1
  docker://registry.example:5000 2
```

1. Pass in the image set configuration file that was created. This procedure assumes that it is named **imageset-config.yaml**.
2. Specify the registry to mirror the image set file to. The registry must start with **docker://**. If you specify a top-level namespace for the mirror registry, you must also use this same namespace on subsequent executions.

Verification

1. Navigate into the **oc-mirror-workspace/** directory that was generated.

2. Navigate into the results directory, for example, **results-1639608409**/.
3. Verify that YAML files are present for the **ImageContentSourcePolicy** and **CatalogSource** resources.

Next steps

- Configure your cluster to use the resources generated by oc-mirror.

Troubleshooting

- Unable to retrieve source image .

3.4.7.2. Mirroring an image set in a fully disconnected environment

To mirror an image set in a fully disconnected environment, you must first mirror the image set to disk , then mirror the image set file on disk to a mirror .

3.4.7.2.1. Mirroring from mirror to disk

You can use the oc-mirror plugin to generate an image set and save the contents to disk. The generated image set can then be transferred to the disconnected environment and mirrored to the target registry.

IMPORTANT

Depending on the configuration specified in the image set configuration file, using oc-mirror to mirror images might download several hundreds of gigabytes of data to disk.

The initial image set download when you populate the mirror registry is often the largest. Because you only download the images that changed since the last time you ran the command, when you run the oc-mirror plugin again, the generated image set is often smaller.

You are required to specify a storage backend in the image set configuration file. This storage backend can be a local directory or a docker v2 registry. The oc-mirror plugin stores metadata in this storage backend during image set creation.

IMPORTANT

Do not delete or modify the metadata that is generated by the oc-mirror plugin. You must use the same storage backend every time you run the oc-mirror plugin for the same mirror registry.

Prerequisites

- You have access to the internet to obtain the necessary container images.
- You have installed the OpenShift CLI (**oc**).
- You have installed the **oc-mirror** CLI plugin.
- You have created the image set configuration file.

Procedure

- Run the **oc mirror** command to mirror the images from the specified image set configuration to disk:

```
$ oc mirror --config=./imageset-config.yaml \ 1
  file://<path_to_output_directory> 2
```

1. Pass in the image set configuration file that was created. This procedure assumes that it is named **imageset-config.yaml**.
2. Specify the target directory where you want to output the image set file. The target directory path must start with **file://**.

Verification

1. Navigate to your output directory:

```
$ cd <path_to_output_directory>
```

2. Verify that an image set **.tar** file was created:

```
$ ls
```

Example output

```
mirror_seq1_000000.tar
```

Next steps

- Transfer the image set .tar file to the disconnected environment.

Troubleshooting

- Unable to retrieve source image .

3.4.7.2.2. Mirroring from disk to mirror

You can use the oc-mirror plugin to mirror the contents of a generated image set to the target mirror registry.

Prerequisites

- You have installed the OpenShift CLI (**oc**) in the disconnected environment.
- You have installed the **oc-mirror** CLI plugin in the disconnected environment.
- You have generated the image set file by using the **oc mirror** command.
- You have transferred the image set file to the disconnected environment.

Procedure

- Run the **oc mirror** command to process the image set file on disk and mirror the contents to a target mirror registry:

```
$ oc mirror --from=./mirror_seq1_000000.tar \ 1
  docker://registry.example:5000              2
```

1. Pass in the image set .tar file to mirror, named **mirror_seq1_000000.tar** in this example. If an **archiveSize** value was specified in the image set configuration file, the image set might be broken up into multiple .tar files. In this situation, you can pass in a directory that contains the image set .tar files.
2. Specify the registry to mirror the image set file to. The registry must start with **docker://**. If you specify a top-level namespace for the mirror registry, you must also use this same namespace on subsequent executions.

This command updates the mirror registry with the image set and generates the **ImageContentSourcePolicy** and **CatalogSource** resources.

Verification

1. Navigate into the **oc-mirror-workspace/** directory that was generated.
2. Navigate into the results directory, for example, **results-1639608409/**.
3. Verify that YAML files are present for the **ImageContentSourcePolicy** and **CatalogSource** resources.

Next steps

- Configure your cluster to use the resources generated by oc-mirror.

Troubleshooting

- Unable to retrieve source image .

3.4.8. Configuring your cluster to use the resources generated by oc-mirror

After you have mirrored your image set to the mirror registry, you must apply the generated **ImageContentSourcePolicy**, **CatalogSource**, and release image signature resources into the cluster.

The **ImageContentSourcePolicy** resource associates the mirror registry with the source registry and redirects image pull requests from the online registries to the mirror registry. The **CatalogSource** resource is used by Operator Lifecycle Manager (OLM) to retrieve information about the available Operators in the mirror registry. The release image signatures are used to verify the mirrored release images.

Prerequisites

- You have mirrored the image set to the registry mirror in the disconnected environment.
- You have access to the cluster as a user with the **cluster-admin** role.

Procedure

1. Log in to the OpenShift CLI as a user with the **cluster-admin** role.
2. Apply the YAML files from the results directory to the cluster by running the following command:

```
$ oc apply -f ./oc-mirror-workspace/results-1639608409/
```

3. If you mirrored release images, apply the release image signatures to the cluster by running the following command:

```
$ oc apply -f ./oc-mirror-workspace/results-1639608409/release-signatures/
```

NOTE

If you are mirroring Operators instead of clusters, you do not need to run **$ oc apply -f ./oc-mirror-workspace/results-1639608409/release-signatures/**. Running that command will return an error, as there are no release image signatures to apply.

Verification

1. Verify that the **ImageContentSourcePolicy** resources were successfully installed by running the following command:

```
$ oc get imagecontentsourcepolicy --all-namespaces
```

2. Verify that the **CatalogSource** resources were successfully installed by running the following command:

```
$ oc get catalogsource --all-namespaces
```

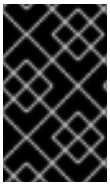
3.4.9. Keeping your mirror registry content updated

After your target mirror registry is populated with the initial image set, be sure to update it regularly so that it has the latest content. You can optionally set up a cron job, if possible, so that the mirror registry is updated on a regular basis.

Ensure that you update your image set configuration to add or remove OpenShift Container Platform and Operator releases as necessary. Any images that are removed are pruned from the mirror registry.

3.4.9.1. About updating your mirror registry content

When you run the oc-mirror plugin again, it generates an image set that only contains new and updated images since the previous execution. Because it only pulls in the differences since the previous image set was created, the generated image set is often smaller and faster to process than the initial image set.



IMPORTANT

Generated image sets are sequential and must be pushed to the target mirror registry in order. You can derive the sequence number from the file name of the generated image set archive file.

Adding new and updated images

Depending on the settings in your image set configuration, future executions of oc-mirror can mirror additional new and updated images. Review the settings in your image set configuration to ensure that you are retrieving new versions as necessary. For example, you can set the minimum and maximum versions of Operators to mirror if you want to restrict to specific versions. Alternatively, you can set the minimum version as a starting point to mirror, but keep the version range open so you keep receiving new Operator versions on future executions of oc-mirror. Omitting any minimum or maximum version gives you the full version history of an Operator in a channel. Omitting explicitly named channels gives you all releases in all channels of the specified Operator. Omitting any named Operator gives you the entire catalog of all Operators and all their versions ever released.

All these constraints and conditions are evaluated against the publicly released content by Red Hat on every invocation of oc-mirror. This way, it automatically picks up new releases and entirely new Operators. Constraints can be specified by only listing a desired set of Operators, which will not automatically add other newly released Operators into the mirror set. You can also specify a particular release channel, which limits mirroring to just this channel and not any new channels that have been added. This is important for Operator products, such as Red Hat Quay, that use different release channels for their minor releases. Lastly, you can specify a maximum version of a particular Operator, which causes the tool to only mirror the specified version range so that you do not automatically get any newer releases past the maximum version mirrored. In all these cases, you must update the image set configuration file to broaden the scope of the mirroring of Operators to get other Operators, new channels, and newer versions of Operators to be available in your target registry.

It is recommended to align constraints like channel specification or version ranges with the release strategy that a particular Operator has chosen. For example, when the Operator uses a **stable** channel, you should restrict mirroring to that channel and potentially a minimum version to find the right balance between download volume and getting stable updates regularly. If the Operator chooses a release version channel scheme, for example **stable-3.7**, you should mirror all releases in that channel. This allows you to keep receiving patch versions of the Operator, for example **3.7.1**. You can also regularly adjust the image set configuration to add channels for new product releases, for example **stable-3.8**.

Pruning images

Images are pruned automatically from the target mirror registry if they are no longer included in the latest image set that was generated and mirrored. This allows you to easily manage and clean up unneeded content and reclaim storage resources.

If there are OpenShift Container Platform releases or Operator versions that you no longer need, you can modify your image set configuration to exclude them, and they will be pruned from the mirror registry upon mirroring. This can be done by adjusting a minimum or maximum version range setting per Operator in the image set configuration file or by deleting the Operator from the list of Operators to mirror from the catalog. You can also remove entire Operator catalogs or entire OpenShift Container Platform releases from the configuration file.

IMPORTANT

If there are no new or updated images to mirror, the excluded images are not pruned from the target mirror registry. Additionally, if an Operator publisher removes an Operator version from a channel, the removed versions are pruned from the target mirror registry.

3.4.9.2. Updating your mirror registry content

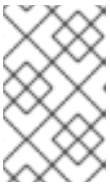
After you publish the initial image set to the mirror registry, you can use the oc-mirror plugin to keep your disconnected clusters updated.

Depending on your image set configuration, oc-mirror automatically detects newer releases of

OpenShift Container Platform and your selected Operators that have been released after you completed the inital mirror. It is recommended to run oc-mirror at regular intervals, for example in a nightly cron job, to receive product and security updates on a timely basis.

Prerequisites

- You have used the oc-mirror plugin to mirror the initial image set to your mirror registry.
- You have access to the storage backend that was used for the initial execution of the oc-mirror plugin.



NOTE

You must use the same storage backend as the initial execution of oc-mirror for the same mirror registry. Do not delete or modify the metadata image that is generated by the oc-mirror plugin.

Procedure

1. If necessary, update your image set configuration file to pick up new OpenShift Container Platform and Operator versions. See *Image set configuration examples* for example mirroring use cases.
2. Follow the same steps that you used to mirror your initial image set to the mirror registry. For instructions, see *Mirroring an image set in a partially disconnected environment* or *Mirroring an image set in a fully disconnected environment*.

IMPORTANT

- You must provide the same storage backend so that only a differential image set is created and mirrored.
- If you specified a top-level namespace for the mirror registry during the initial image set creation, then you must use this same namespace every time you run the oc-mirror plugin for the same mirror registry.

3. Configure your cluster to use the resources generated by oc-mirror.

Additional resources

- Image set configuration examples
- Mirroring an image set in a partially disconnected environment
- Mirroring an image set in a fully disconnected environment
- Configuring your cluster to use the resources generated by oc-mirror

3.4.10. Performing a dry run

You can use oc-mirror to perform a dry run, without actually mirroring any images. This allows you to review the list of images that would be mirrored, as well as any images that would be pruned from the mirror registry. It also allows you to catch any errors with your image set configuration early or use the generated list of images with other tools to carry out the mirroring operation.

Prerequisites

- You have access to the internet to obtain the necessary container images.
- You have installed the OpenShift CLI (**oc**).
- You have installed the **oc-mirror** CLI plugin.
- You have created the image set configuration file.

Procedure

1. Run the **oc mirror** command with the **--dry-run** flag to perform a dry run:

```
$ oc mirror --config=./imageset-config.yaml \ 1
  docker://registry.example:5000           \ 2
  --dry-run                                  3
```

1. Pass in the image set configuration file that was created. This procedure assumes that it is named **imageset-config.yaml**.
2. Specify the mirror registry. Nothing is mirrored to this registry as long as you use the **--dry-run** flag.
3. Use the **--dry-run** flag to generate the dry run artifacts and not an actual image set file.

Example output

```
Checking push permissions for registry.example:5000
Creating directory: oc-mirror-workspace/src/publish
Creating directory: oc-mirror-workspace/src/v2
Creating directory: oc-mirror-workspace/src/charts
Creating directory: oc-mirror-workspace/src/release-signatures
No metadata detected, creating new workspace
wrote mirroring manifests to oc-mirror-workspace/operators.1658342351/manifests-redhat-operator-index

...

info: Planning completed in 31.48s
info: Dry run complete
Writing image mapping to oc-mirror-workspace/mapping.txt
```

2. Navigate into the workspace directory that was generated:

```
$ cd oc-mirror-workspace/
```

3. Review the **mapping.txt** file that was generated.
   This file contains a list of all images that would be mirrored.
4. Review the **pruning-plan.json** file that was generated.
   This file contains a list of all images that would be pruned from the mirror registry when the image set is published.

NOTE

The **pruning-plan.json** file is only generated if your oc-mirror command points to your mirror registry and there are images to be pruned.

3.4.11. Image set configuration parameters

The oc-mirror plugin requires an image set configuration file that defines what images to mirror. The following table lists the available parameters for the **ImageSetConfiguration** resource.

Table 3.1. **ImageSetConfiguration** parameters

Parameter	Description	Values
apiVersion	The API version for the **ImageSetConfiguration** content.	String. For example: **mirror.openshift.io/v1alpha2**.
archiveSize	The maximum size, in GiB, of each archive file within the image set.	Integer. For example: **4**
mirror	The configuration of the image set.	Object
mirror.additionalImages	The additional images configuration of the image set.	Array of objects. For example: `additionalImages:` `  - name: registry.redhat.io/ubi8/ubi:latest`
mirror.additionalImages.name	The tag or digest of the image to mirror.	String. For example: **registry.redhat.io/ubi8/ubi:latest**
mirror.blockedImages	The full tag, digest, or pattern of images to block from mirroring.	Array of strings. For example: **docker.io/library/alpine**
mirror.helm	The helm configuration of the image set. Note that the oc-mirror plugin supports only helm charts that do not require user input when rendered.	Object

Parameter	Description	Values
mirror.helm.local	The local helm charts to mirror.	Array of objects. For example: `local:` `- name: podinfo` `path: /test/podinfo-5.0.0.tar.gz`
mirror.helm.local.name	The name of the local helm chart to mirror.	String. For example: **podinfo**.
mirror.helm.local.path	The path of the local helm chart to mirror.	String. For example: **/test/podinfo-5.0.0.tar.gz**.
mirror.helm.repositories	The remote helm repositories to mirror from.	Array of objects. For example: `repositories:` `- name: podinfo` `url: https://example.github.io/podinfo` `charts:` `- name: podinfo` `version: 5.0.0`
mirror.helm.repositories.name	The name of the helm repository to mirror from.	String. For example: **podinfo**.
mirror.helm.repositories.url	The URL of the helm repository to mirror from.	String. For example: **https://example.github.io/podinfo**.
mirror.helm.repositories.charts	The remote helm charts to mirror.	Array of objects.
mirror.helm.repositories.charts.name	The name of the helm chart to mirror.	String. For example: **podinfo**.

Parameter	Description	Values
mirror.helm.repositories.charts.version	The version of the named helm chart to mirror.	String. For example: **5.0.0**.
mirror.operators	The Operators configuration of the image set.	Array of objects. For example: operators: - catalog: registry.redhat.io/redhat/redhat-operator-index:v4.11 packages: - name: elasticsearch-operator minVersion: '2.4.0'
mirror.operators.catalog	The Operator catalog to include in the image set.	String. For example: **registry.redhat.io/redhat/redhat-operator-index:v4.11**.
mirror.operators.full	When **true**, downloads the full catalog, Operator package, or Operator channel.	Boolean. The default value is **false**.
mirror.operators.packages	The Operator packages configuration.	Array of objects. For example: operators: - catalog: registry.redhat.io/redhat/redhat-operator-index:v4.11 packages: - name: elasticsearch-operator minVersion: '5.2.3-31'

Parameter	Description	Values
mirror.operators.packages.name	The Operator package name to include in the image set	String. For example: **elasticsearch-operator**.
mirror.operators.packages.channels	The Operator package channel configuration.	Object
mirror.operators.packages.channels.name	The Operator channel name, unique within a package, to include in the image set.	String. For example: **fast** or **stable-v4.11**.
mirror.operators.packages.channels.maxVersion	The highest version of the Operator mirror across all channels in which it exists.	String. For example: **5.2.3-31**
mirror.operators.packages.channels.minBundle	The name of the minimum bundle to include, plus all bundles in the upgrade graph to the channel head. Set this field only if the named bundle has no semantic version metadata.	String. For example: **bundleName**
mirror.operators.packages.channels.minVersion	The lowest version of the Operator to mirror across all channels in which it exists.	String. For example: **5.2.3-31**
mirror.operators.packages.maxVersion	The highest version of the Operator to mirror across all channels in which it exists.	String. For example: **5.2.3-31**.
mirror.operators.packages.minVersion	The lowest version of the Operator to mirror across all channels in which it exists.	String. For example: **5.2.3-31**.
mirror.operators.skipDependencies	If **true**, dependencies of bundles are not included.	Boolean. The default value is **false**.
mirror.operators.targetName	Optional alternative name to mirror the referenced catalog as.	String. For example: **my-operator-catalog**
mirror.operators.targetTag	Optional alternative tag to append to the **targetName**.	String. For example: **v1**

Parameter	Description	Values
mirror.platform	The platform configuration of the image set.	Object
mirror.platform.architectures	The architecture of the platform release payload to mirror.	Array of strings. For example: `architectures:` `- amd64` `- arm64`
mirror.platform.channels	The platform channel configuration of the image set.	Array of objects. For example: `channels:` `- name: stable-4.10` `- name: stable-4.11`
mirror.platform.channels.full	When **true**, sets the **minVersion** to the first release in the channel and the **maxVersion** to the last release in the channel.	Boolean. The default value is **false**.
mirror.platform.channels.name	The name of the release channel.	String. For example: **stable-4.11**
mirror.platform.channels.minVersion	The minimum version of the referenced platform to be mirrored.	String. For example: **4.9.6**
mirror.platform.channels.maxVersion	The highest version of the referenced platform to be mirrored.	String. For example: **4.11.1**
mirror.platform.channels.shortestPath	Toggles shortest path mirroring or full range mirroring.	Boolean. The default value is **false**.
mirror.platform.channels.type	The type of the platform to be mirrored.	String. For example: **ocp** or **okd**. The default is **ocp**.
mirror.platform.graph	Indicates whether the OSUS graph is added to the image set and subsequently published to the mirror.	Boolean. The default value is **false**.

Parameter	Description	Values
storageConfig	The back-end configuration of the image set.	Object
storageConfig.local	The local back-end configuration of the image set.	Object
storageConfig.local.path	The path of the directory to contain the image set metadata.	String. For example: **./path/to/dir/**.
storageConfig.registry	The registry back-end configuration of the image set.	Object
storageConfig.registry.imageURL	The back-end registry URI. Can optionally include a namespace reference in the URI.	String. For example: **quay.io/myuser/imageset:metadata**.
storageConfig.registry.skipTLS	Optionally skip TLS verification of the referenced back-end registry.	Boolean. The default value is **false**.

3.4.12. Image set configuration examples

The following **ImageSetConfiguration** file examples show the configuration for various mirroring use cases.

Use case: Including arbitrary images and helm charts
The following **ImageSetConfiguration** file uses a registry storage backend and includes helm charts and an additional Red Hat Universal Base Image (UBI).

Example ImageSetConfiguration file

```
apiVersion: mirror.openshift.io/v1alpha2
kind: ImageSetConfiguration
archiveSize: 4
storageConfig:
 registry:
   imageURL: example.com/mirror/oc-mirror-metadata
   skipTLS: false
mirror:
 platform:
   architectures:
     - "s390x"
   channels:
     - name: stable-4.11
 operators:
   - catalog: registry.redhat.io/redhat/redhat-operator-index:v4.11
 helm:
```

```
    repositories:
      - name: redhat-helm-charts
        url: https://raw.githubusercontent.com/redhat-developer/redhat-helm-charts/master
        charts:
          - name: ibm-mongodb-enterprise-helm
            version: 0.2.0
  additionalImages:
    - name: registry.redhat.io/ubi8/ubi:latest
```

Use case: Including Operator versions from a minimum to the latest
The following **ImageSetConfiguration** file uses a local storage backend and includes only the Red Hat Advanced Cluster Security for Kubernetes Operator, versions starting at 3.68.0 and later in the **latest** channel.

Example ImageSetConfiguration file

```
apiVersion: mirror.openshift.io/v1alpha2
kind: ImageSetConfiguration
storageConfig:
  local:
    path: /home/user/metadata
mirror:
  operators:
    - catalog: registry.redhat.io/redhat/redhat-operator-index:v4.11
      packages:
        - name: rhacs-operator
          channels:
          - name: latest
            minVersion: 3.68.0
```

Use case: Including the shortest OpenShift Container Platform upgrade path
The following **ImageSetConfiguration** file uses a local storage backend and includes all OpenShift Container Platform versions along the shortest upgrade path from the minimum version of **4.9.37** to the maximum version of **4.10.22**.

Example ImageSetConfiguration file

```
apiVersion: mirror.openshift.io/v1alpha2
kind: ImageSetConfiguration
storageConfig:
  local:
    path: /home/user/metadata
mirror:
  platform:
    channels:
      - name: stable-4.10
        minVersion: 4.9.37
        maxVersion: 4.10.22
        shortestPath: true
```

Use case: Including all versions of OpenShift Container Platform from a minimum to the latest
The following **ImageSetConfiguration** file uses a registry storage backend and includes all OpenShift Container Platform versions starting at a minimum version of **4.10.10** to the latest version in the channel.

On every invocation of oc-mirror with this image set configuration, the latest release of the **stable-4.10** channel is evaluated, so running oc-mirror at regular intervals ensures that you automatically receive the latest releases of OpenShift Container Platform images.

Example ImageSetConfiguration file

```
apiVersion: mirror.openshift.io/v1alpha2
kind: ImageSetConfiguration
storageConfig:
 registry:
   imageURL: example.com/mirror/oc-mirror-metadata
   skipTLS: false
mirror:
  platform:
    channels:
      - name: stable-4.10
        minVersion: 4.10.10
```

Use case: Including Operator versions from a minimum to a maximum
The following **ImageSetConfiguration** file uses a local storage backend and includes only an example Operator, versions starting at **1.0.0** through **2.0.0** in the **stable** channel.

This allows you to only mirror a specific version range of a particular Operator. As time progresses, you can use these settings to adjust the version to newer releases, for example when you no longer have version **1.0.0** running anywhere anymore. In this scenario, you can increase the **minVersion** to something newer, for example **1.5.0**. When oc-mirror runs again with the updated version range, it automatically detects that any releases older than **1.5.0** are no longer required and deletes those from the registry to conserve storage space.

Example ImageSetConfiguration file

```
apiVersion: mirror.openshift.io/v1alpha2
kind: ImageSetConfiguration
storageConfig:
  local:
    path: /home/user/metadata
mirror:
  operators:
    - catalog: registry.redhat.io/redhat/redhat-operator-index:v4.11
      packages:
        - name: example-operator
          channels:
            - name: stable
              minVersion: '1.0.0'
              maxVersion: '2.0.0'
```

3.4.13. Command reference for oc-mirror

The following tables describe the **oc mirror** subcommands and flags:

Table 3.2. oc mirror subcommands

Subcommand	Description
completion	Generate the autocompletion script for the specified shell.
describe	Output the contents of an image set.
help	Show help about any subcommand.
init	Output an initial image set configuration template.
list	List available platform and Operator content and their version.
version	Output the oc-mirror version.

Table 3.3. oc mirror flags

Flag	Description
-c, **--config <string>**	Specify the path to an image set configuration file.
--continue-on-error	If any non image-pull related error occurs, continue and attempt to mirror as much as possible.
--dest-skip-tls	Disable TLS validation for the target registry.
--dest-use-http	Use plain HTTP for the target registry.
--dry-run	Print actions without mirroring images. Generates **mapping.txt** and **pruning-plan.json** files.
--from <string>	Specify the path to an image set archive that was generated by an execution of oc-mirror to load into a target registry.
-h, **--help**	Show the help.
--ignore-history	Ignore past mirrors when downloading images and packing layers. Disables incremental mirroring and might download more data.
--manifests-only	Generate manifests for **ImageContentSourcePolicy** objects to configure a cluster to use the mirror registry, but do not actually mirror any images. To use this flag, you must pass in an image set archive with the **--from** flag.
--max-per-registry <int>	Specify the number of concurrent requests allowed per registry. The default is **6**.
--skip-cleanup	Skip removal of artifact directories.

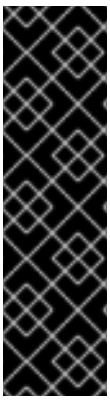
Flag	Description
--skip-image-pin	Do not replace image tags with digest pins in Operator catalogs.
--skip-metadata-check	Skip metadata when publishing an image set. This is only recommended when the image set was created with **--ignore-history**.
--skip-missing	If an image is not found, skip it instead of reporting an error and aborting execution. Does not apply to custom images explicitly specified in the image set configuration.
--skip-verification	Skip digest verification.
--source-skip-tls	Disable TLS validation for the source registry.
--source-use-http	Use plain HTTP for the source registry.
-v, **--verbose <int>**	Specify the number for the log level verbosity. Valid values are **0** - **9**. The default is **0**.

3.4.14. Additional resources

- About cluster updates in a disconnected environment

CHAPTER 4. INSTALLING ON ALIBABA

4.1. PREPARING TO INSTALL ON ALIBABA CLOUD



IMPORTANT

Alibaba Cloud on OpenShift Container Platform is a Technology Preview feature only. Technology Preview features are not supported with Red Hat production service level agreements (SLAs) and might not be functionally complete. Red Hat does not recommend using them in production. These features provide early access to upcoming product features, enabling customers to test functionality and provide feedback during the development process.

For more information about the support scope of Red Hat Technology Preview features, see Technology Preview Features Support Scope .

4.1.1. Prerequisites

- You reviewed details about the OpenShift Container Platform installation and update processes.
- You read the documentation on selecting a cluster installation method and preparing it for users.

4.1.2. Requirements for installing OpenShift Container Platform on Alibaba Cloud

Before installing OpenShift Container Platform on Alibaba Cloud, you must configure and register your domain, create a Resource Access Management (RAM) user for the installation, and review the supported Alibaba Cloud data center regions and zones for the installation.

4.1.3. Registering and Configuring Alibaba Cloud Domain

To install OpenShift Container Platform, the Alibaba Cloud account you use must have a dedicated public hosted zone in your account. This zone must be authoritative for the domain. This service provides cluster DNS resolution and name lookup for external connections to the cluster.

Procedure

1. Identify your domain, or subdomain, and registrar. You can transfer an existing domain and registrar or obtain a new one through Alibaba Cloud or another source.

NOTE

If you purchase a new domain through Alibaba Cloud, it takes time for the relevant DNS changes to propagate. For more information about purchasing domains through Alibaba Cloud, see Alibaba Cloud domains.

2. If you are using an existing domain and registrar, migrate its DNS to Alibaba Cloud. See Domain name transfer in the Alibaba Cloud documentation.
3. Configure DNS for your domain. This includes:
   - Registering a generic domain name .

- Completing real-name verification for your domain name .
- Applying for an Internet Content Provider (ICP) filing .
- Enabling domain name resolution.
  Use an appropriate root domain, such as **openshiftcorp.com**, or subdomain, such as **clusters.openshiftcorp.com**.

4. If you are using a subdomain, follow the procedures of your company to add its delegation records to the parent domain.

4.1.4. Supported Alibaba regions

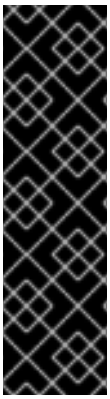
You can deploy an OpenShift Container Platform cluster to the regions listed in the Alibaba *Regions and zones* documentation.

4.1.5. Next steps

- Create the required Alibaba Cloud resources .

4.2. CREATING THE REQUIRED ALIBABA CLOUD RESOURCES

Before you install OpenShift Container Platform, you must use the Alibaba Cloud console to create a Resource Access Management (RAM) user that has sufficient permissions to install OpenShift Container Platform into your Alibaba Cloud. This user must also have permissions to create new RAM users. You can also configure and use the **ccoctl** tool to create new credentials for the OpenShift Container Platform components with the permissions that they require.



IMPORTANT

Alibaba Cloud on OpenShift Container Platform is a Technology Preview feature only. Technology Preview features are not supported with Red Hat production service level agreements (SLAs) and might not be functionally complete. Red Hat does not recommend using them in production. These features provide early access to upcoming product features, enabling customers to test functionality and provide feedback during the development process.

For more information about the support scope of Red Hat Technology Preview features, see Technology Preview Features Support Scope .

4.2.1. Creating the required RAM user

You must have a Alibaba Cloud Resource Access Management (RAM) user for the installation that has sufficient privileges. You can use the Alibaba Cloud Resource Access Management console to create a new user or modify an existing user. Later, you create credentials in OpenShift Container Platform based on this user's permissions.

When you configure the RAM user, be sure to consider the following requirements:

- The user must have an Alibaba Cloud AccessKey ID and AccessKey secret pair.
  - For a new user, you can select **Open API Access** for the Access Mode when creating the user. This mode generates the required AccessKey pair.

- For an existing user, you can add an AccessKey pair or you can obtain the AccessKey pair for that user.

NOTE

When created, the AccessKey secret is displayed only once. You must immediately save the AccessKey pair because the AccessKey pair is required for API calls.

- Add the AccessKey ID and secret to the **~/.alibabacloud/credentials** file on your local computer. Alibaba Cloud automatically creates this file when you log in to the console. The Cloud Credential Operator (CCO) utility, ccoutil, uses these credentials when processing **Credential Request** objects.
  For example:

```
[default]                    # Default client
type = access_key            # Certification type: access_key
access_key_id = LTAI5t8cefXKmt          # Key (1)
access_key_secret = wYx56mszAN4Uunfh    # Secret
```

(1) Add your AccessKeyID and AccessKeySecret here.

- The RAM user must have the **AdministratorAccess** policy to ensure that the account has sufficient permission to create the OpenShift Container Platform cluster. This policy grants permissions to manage all Alibaba Cloud resources.
  When you attach the **AdministratorAccess** policy to a RAM user, you grant that user full access to all Alibaba Cloud services and resources. If you do not want to create a user with full access, create a custom policy with the following actions that you can add to your RAM user for installation. These actions are sufficient to install OpenShift Container Platform.

TIP

You can copy and paste the following JSON code into the Alibaba Cloud console to create a custom poicy. For information on creating custom policies, see Create a custom policy in the Alibaba Cloud documentation.

Example 4.1. Example custom policy JSON file

```
{
  "Version": "1",
  "Statement": [
    {
      "Action": [
        "tag:ListTagResources",
        "tag:UntagResources"
      ],
      "Resource": "*",
      "Effect": "Allow"
    },
    {
      "Action": [
        "vpc:DescribeVpcs",
        "vpc:DeleteVpc",
```

```
        "vpc:DescribeVSwitches",
        "vpc:DeleteVSwitch",
        "vpc:DescribeEipAddresses",
        "vpc:DescribeNatGateways",
        "vpc:ReleaseEipAddress",
        "vpc:DeleteNatGateway",
        "vpc:DescribeSnatTableEntries",
        "vpc:CreateSnatEntry",
        "vpc:AssociateEipAddress",
        "vpc:ListTagResources",
        "vpc:TagResources",
        "vpc:DescribeVSwitchAttributes",
        "vpc:CreateVSwitch",
        "vpc:CreateNatGateway",
        "vpc:DescribeRouteTableList",
        "vpc:CreateVpc",
        "vpc:AllocateEipAddress",
        "vpc:ListEnhanhcedNatGatewayAvailableZones"
      ],
      "Resource": "*",
      "Effect": "Allow"
    },
    {
      "Action": [
        "ecs:ModifyInstanceAttribute",
        "ecs:DescribeSecurityGroups",
        "ecs:DeleteSecurityGroup",
        "ecs:DescribeSecurityGroupReferences",
        "ecs:DescribeSecurityGroupAttribute",
        "ecs:RevokeSecurityGroup",
        "ecs:DescribeInstances",
        "ecs:DeleteInstances",
        "ecs:DescribeNetworkInterfaces",
        "ecs:DescribeInstanceRamRole",
        "ecs:DescribeUserData",
        "ecs:DescribeDisks",
        "ecs:ListTagResources",
        "ecs:AuthorizeSecurityGroup",
        "ecs:RunInstances",
        "ecs:TagResources",
        "ecs:ModifySecurityGroupPolicy",
        "ecs:CreateSecurityGroup",
        "ecs:DescribeAvailableResource",
        "ecs:DescribeRegions",
        "ecs:AttachInstanceRamRole"
      ],
      "Resource": "*",
      "Effect": "Allow"
    },
    {
      "Action": [
        "pvtz:DescribeRegions",
        "pvtz:DescribeZones",
        "pvtz:DeleteZone",
        "pvtz:DeleteZoneRecord",
        "pvtz:BindZoneVpc",
```

```
        "pvtz:DescribeZoneRecords",
        "pvtz:AddZoneRecord",
        "pvtz:SetZoneRecordStatus",
        "pvtz:DescribeZoneInfo",
        "pvtz:DescribeSyncEcsHostTask",
        "pvtz:AddZone"
      ],
      "Resource": "*",
      "Effect": "Allow"
    },
    {
      "Action": [
        "slb:DescribeLoadBalancers",
        "slb:SetLoadBalancerDeleteProtection",
        "slb:DeleteLoadBalancer",
        "slb:SetLoadBalancerModificationProtection",
        "slb:DescribeLoadBalancerAttribute",
        "slb:AddBackendServers",
        "slb:DescribeLoadBalancerTCPListenerAttribute",
        "slb:SetLoadBalancerTCPListenerAttribute",
        "slb:StartLoadBalancerListener",
        "slb:CreateLoadBalancerTCPListener",
        "slb:ListTagResources",
        "slb:TagResources",
        "slb:CreateLoadBalancer"
      ],
      "Resource": "*",
      "Effect": "Allow"
    },
    {
      "Action": [
        "ram:ListResourceGroups",
        "ram:DeleteResourceGroup",
        "ram:ListPolicyAttachments",
        "ram:DetachPolicy",
        "ram:GetResourceGroup",
        "ram:CreateResourceGroup",
        "ram:DeleteRole",
        "ram:GetPolicy",
        "ram:DeletePolicy",
        "ram:ListPoliciesForRole",
        "ram:CreateRole",
        "ram:AttachPolicyToRole",
        "ram:GetRole",
        "ram:CreatePolicy",
        "ram:CreateUser",
        "ram:DetachPolicyFromRole",
        "ram:CreatePolicyVersion",
        "ram:DetachPolicyFromUser",
        "ram:ListPoliciesForUser",
        "ram:AttachPolicyToUser",
        "ram:CreateUser",
        "ram:GetUser",
        "ram:DeleteUser",
        "ram:CreateAccessKey",
        "ram:ListAccessKeys",
```

```
      "ram:DeleteAccessKey",
      "ram:ListUsers",
      "ram:ListPolicyVersions"
    ],
    "Resource": "*",
    "Effect": "Allow"
  },
  {
    "Action": [
      "oss:DeleteBucket",
      "oss:DeleteBucketTagging",
      "oss:GetBucketTagging",
      "oss:GetBucketCors",
      "oss:GetBucketPolicy",
      "oss:GetBucketLifecycle",
      "oss:GetBucketReferer",
      "oss:GetBucketTransferAcceleration",
      "oss:GetBucketLog",
      "oss:GetBucketWebSite",
      "oss:GetBucketInfo",
      "oss:PutBucketTagging",
      "oss:PutBucket",
      "oss:OpenOssService",
      "oss:ListBuckets",
      "oss:GetService",
      "oss:PutBucketACL",
      "oss:GetBucketLogging",
      "oss:ListObjects",
      "oss:GetObject",
      "oss:PutObject",
      "oss:DeleteObject"
    ],
    "Resource": "*",
    "Effect": "Allow"
  },
  {
    "Action": [
      "alidns:DescribeDomainRecords",
      "alidns:DeleteDomainRecord",
      "alidns:DescribeDomains",
      "alidns:DescribeDomainRecordInfo",
      "alidns:AddDomainRecord",
      "alidns:SetDomainRecordStatus"
    ],
    "Resource": "*",
    "Effect": "Allow"
  },
  {
    "Action": "bssapi:CreateInstance",
    "Resource": "*",
    "Effect": "Allow"
  },
  {
    "Action": "ram:PassRole",
    "Resource": "*",
    "Effect": "Allow",
```

```
        "Condition": {
          "StringEquals": {
            "acs:Service": "ecs.aliyuncs.com"
          }
        }
      }
    ]
  }
```

For more information about creating a RAM user and granting permissions, see Create a RAM user and Grant permissions to a RAM user in the Alibaba Cloud documentation.

4.2.2. Configuring the Cloud Credential Operator utility

To assign RAM users and policies that provide long-lived RAM AccessKeys (AKs) for each in-cluster component, extract and prepare the Cloud Credential Operator (CCO) utility (**ccoctl**) binary.

NOTE

The **ccoctl** utility is a Linux binary that must run in a Linux environment.

Prerequisites

- You have access to an OpenShift Container Platform account with cluster administrator access.
- You have installed the OpenShift CLI (**oc**).

Procedure

1. Obtain the OpenShift Container Platform release image by running the following command:

```
$ RELEASE_IMAGE=$(./openshift-install version | awk '/release image/ {print $3}')
```

2. Obtain the CCO container image from the OpenShift Container Platform release image by running the following command:

```
$ CCO_IMAGE=$(oc adm release info --image-for='cloud-credential-operator'
$RELEASE_IMAGE -a ~/.pull-secret)
```

NOTE

Ensure that the architecture of the **$RELEASE_IMAGE** matches the architecture of the environment in which you will use the **ccoctl** tool.

3. Extract the **ccoctl** binary from the CCO container image within the OpenShift Container Platform release image by running the following command:

```
$ oc image extract $CCO_IMAGE --file="/usr/bin/ccoctl" -a ~/.pull-secret
```

4. Change the permissions to make **ccoctl** executable by running the following command:

```
$ chmod 775 ccoctl
```

Verification

- To verify that **ccoctl** is ready to use, display the help file by running the following command:

```
$ ccoctl --help
```

Output of ccoctl --help

```
OpenShift credentials provisioning tool

Usage:
  ccoctl [command]

Available Commands:
  alibabacloud Manage credentials objects for alibaba cloud
  aws          Manage credentials objects for AWS cloud
  gcp          Manage credentials objects for Google cloud
  help         Help about any command
  ibmcloud     Manage credentials objects for IBM Cloud
  nutanix      Manage credentials objects for Nutanix

Flags:
  -h, --help   help for ccoctl

Use "ccoctl [command] --help" for more information about a command.
```

Additional resources

- Preparing to update a cluster with manually maintained credentials

4.2.3. Next steps

- Install a cluster on Alibaba Cloud infrastructure that is provisioned by the OpenShift Container Platform installation program, by using one of the following methods:
  - **Installing a cluster quickly on Alibaba Cloud** You can install a cluster quickly by using the default configuration options.
  - **Installing a customized cluster on Alibaba Cloud** The installation program allows for some customization to be applied at the installation stage. Many other customization options are available post-installation.

4.3. INSTALLING A CLUSTER QUICKLY ON ALIBABA CLOUD

In OpenShift Container Platform version 4.11, you can install a cluster on Alibaba Cloud that uses the default configuration options.

IMPORTANT

Alibaba Cloud on OpenShift Container Platform is a Technology Preview feature only. Technology Preview features are not supported with Red Hat production service level agreements (SLAs) and might not be functionally complete. Red Hat does not recommend using them in production. These features provide early access to upcoming product features, enabling customers to test functionality and provide feedback during the development process.

For more information about the support scope of Red Hat Technology Preview features, see Technology Preview Features Support Scope .

4.3.1. Prerequisites

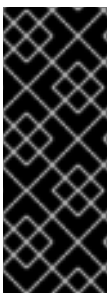
- You reviewed details about the OpenShift Container Platform installation and update processes.
- You read the documentation on selecting a cluster installation method and preparing it for users.
- You registered your domain.
- If you use a firewall, you configured it to allow the sites that your cluster requires access to.
- You have created the required Alibaba Cloud resources .
- If the cloud Resource Access Management (RAM) APIs are not accessible in your environment, or if you do not want to store an administrator-level credential secret in the kube-system namespace, you can manually create and maintain Resource Access Management (RAM) credentials.

4.3.2. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.11, you require access to the internet to install your cluster.

You must have internet access to:

- Access OpenShift Cluster Manager Hybrid Cloud Console to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access Quay.io to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.



IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

4.3.3. Generating a key pair for cluster node SSH access

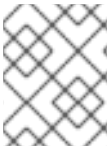
During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the **~/.ssh/authorized_keys** list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The **./openshift-install gather** command also requires the SSH public key to be in place on the cluster nodes.

IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.



NOTE

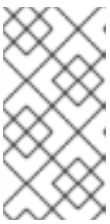
You must use a local key, not one that you configured with platform-specific approaches such as AWS key pairs.

Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N '' -f <path>/<file_name> 1
```

1 Specify the path and file name, such as **~/.ssh/id_ed25519**, of the new SSH key. If you have an existing key pair, ensure your public key is in the your **~/.ssh** directory.



NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS validated or Modules In Process cryptographic libraries on the **x86_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the **~/.ssh/id_ed25519.pub** public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the **./openshift-install gather** command.

NOTE

On some distributions, default SSH private key identities such as **~/.ssh/id_rsa** and **~/.ssh/id_dsa** are managed automatically.

   a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

Example output

```
Agent pid 31874
```

NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

1 Specify the path and file name for your SSH private key, such as **~/.ssh/id_ed25519**

Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

4.3.4. Obtaining the installation program

Before you install OpenShift Container Platform, download the installation file on a local computer.

Prerequisites

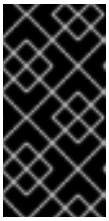
- You have a computer that runs Linux or macOS, with 500 MB of local disk space.

Procedure

1. Access the Infrastructure Provider page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.

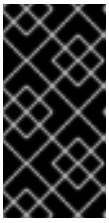
2. Select your infrastructure provider.

3. Navigate to the page for your installation type, download the installation program that corresponds with your host operating system and architecture, and place the file in the directory where you will store the installation configuration files.



IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.



IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation pull secret from the Red Hat OpenShift Cluster Manager . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

4.3.5. Creating the installation configuration file

You can customize the OpenShift Container Platform cluster you install on Alibaba Cloud.

Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.
- Obtain service principal permissions at the subscription level.

Procedure

1. Create the **install-config.yaml** file.

   a. Change to the directory that contains the installation program and run the following command:

```
$ ./openshift-install create install-config --dir <installation_directory> 1
```

   1 For **<installation_directory>**, specify the directory name to store the files that the installation program creates.

When specifying the directory:

- Verify that the directory has the **execute** permission. This permission is required to run Terraform binaries under the installation directory.
- Use an empty directory. Some installation assets, such as bootstrap X.509 certificates, have short expiration intervals, therefore you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

b. At the prompts, provide the configuration details for your cloud:

i. Optional: Select an SSH key to use to access your cluster machines.

NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

ii. Select **alibabacloud** as the platform to target.

iii. Select the region to deploy the cluster to.

iv. Select the base domain to deploy the cluster to. The base domain corresponds to the public DNS zone that you created for your cluster.

v. Provide a descriptive name for your cluster.

vi. Paste the pull secret from the Red Hat OpenShift Cluster Manager .

2. Installing the cluster into Alibaba Cloud requires that the Cloud Credential Operator (CCO) operate in manual mode. Modify the **install-config.yaml** file to set the **credentialsMode** parameter to **Manual**:

Example install-config.yaml configuration file with credentialsMode set to Manual

```
apiVersion: v1
baseDomain: cluster1.example.com
credentialsMode: Manual 1
compute:
- architecture: amd64
  hyperthreading: Enabled
...
```

1 Add this line to set the **credentialsMode** to **Manual**.

3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.

IMPORTANT

The **install-config.yaml** file is consumed during the installation process. If you want to reuse the file, you must back it up now.

4.3.6. Generating the required installation manifests

You must generate the Kubernetes manifest and Ignition config files that the cluster needs to configure the machines.

Procedure

1. Generate the manifests by running the following command from the directory that contains the installation program:

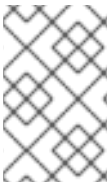
```
$ openshift-install create manifests --dir <installation_directory>
```

where:

<installation_directory>
Specifies the directory in which the installation program creates files.

4.3.7. Creating credentials for OpenShift Container Platform components with the ccoctl tool

You can use the OpenShift Container Platform Cloud Credential Operator (CCO) utility to automate the creation of Alibaba Cloud RAM users and policies for each in-cluster component.



NOTE

By default, **ccoctl** creates objects in the directory in which the commands are run. To create the objects in a different directory, use the **--output-dir** flag. This procedure uses **<path_to_ccoctl_output_dir>** to refer to this directory.

Prerequisites

You must have:

- Extracted and prepared the **ccoctl** binary.
- Created a RAM user with sufficient permission to create the OpenShift Container Platform cluster.
- Added the AccessKeyID (**access_key_id**) and AccessKeySecret (**access_key_secret**) of that RAM user into the **~/.alibabacloud/credentials** file on your local computer.

Procedure

1. Set the **$RELEASE_IMAGE** variable by running the following command:

```
$ RELEASE_IMAGE=$(./openshift-install version | awk '/release image/ {print $3}')
```

2. Extract the list of **CredentialsRequest** objects from the OpenShift Container Platform release image by running the following command:

```
$ oc adm release extract \
--credentials-requests \
--cloud=alibabacloud \
--to=<path_to_directory_with_list_of_credentials_requests>/credrequests \ 1
$RELEASE_IMAGE
```

1 **credrequests** is the directory where the list of **CredentialsRequest** objects is stored. This command creates the directory if it does not exist.

NOTE

This command can take a few moments to run.

3. If your cluster uses cluster capabilities to disable one or more optional components, delete the **CredentialsRequest** custom resources for any disabled components.

Example credrequests directory contents for OpenShift Container Platform 4.12 on Alibaba Cloud

```
0000_30_machine-api-operator_00_credentials-request.yaml 1
0000_50_cluster-image-registry-operator_01-registry-credentials-request-alibaba.yaml 2
0000_50_cluster-ingress-operator_00-ingress-credentials-request.yaml 3
0000_50_cluster-storage-operator_03_credentials_request_alibaba.yaml 4
```

1 The Machine API Operator CR is required.

2 The Image Registry Operator CR is required.

3 The Ingress Operator CR is required.

4 The Storage Operator CR is an optional component and might be disabled in your cluster.

4. Use the **ccoctl** tool to process all **CredentialsRequest** objects in the **credrequests** directory:

   a. Run the following command to use the tool:

```
$ ccoctl alibabacloud create-ram-users \
--name <name> \
--region=<alibaba_region> \
--credentials-requests-dir=
<path_to_directory_with_list_of_credentials_requests>/credrequests \
--output-dir=<path_to_ccoctl_output_dir>
```

   where:

   - **<name>** is the name used to tag any cloud resources that are created for tracking.
   - **<alibaba_region>** is the Alibaba Cloud region in which cloud resources will be created.
   - **<path_to_directory_with_list_of_credentials_requests>/credrequests** is the directory containing the files for the component **CredentialsRequest** objects.

- **<path_to_ccoctl_output_dir>** is the directory where the generated component credentials secrets will be placed.

NOTE

If your cluster uses Technology Preview features that are enabled by the **TechPreviewNoUpgrade** feature set, you must include the **--enable-tech-preview** parameter.

Example output

```
2022/02/11 16:18:26 Created RAM User: user1-alicloud-openshift-machine-api-alibabacloud-credentials
2022/02/11 16:18:27 Ready for creating new ram policy user1-alicloud-openshift-machine-api-alibabacloud-credentials-policy-policy
2022/02/11 16:18:27 RAM policy user1-alicloud-openshift-machine-api-alibabacloud-credentials-policy-policy has created
2022/02/11 16:18:28 Policy user1-alicloud-openshift-machine-api-alibabacloud-credentials-policy-policy has attached on user user1-alicloud-openshift-machine-api-alibabacloud-credentials
2022/02/11 16:18:29 Created access keys for RAM User: user1-alicloud-openshift-machine-api-alibabacloud-credentials
2022/02/11 16:18:29 Saved credentials configuration to: user1-alicloud/manifests/openshift-machine-api-alibabacloud-credentials-credentials.yaml
...
```

NOTE

A RAM user can have up to two AccessKeys at the same time. If you run **ccoctl alibabacloud create-ram-users** more than twice, the previous generated manifests secret becomes stale and you must reapply the newly generated secrets.

b. Verify that the OpenShift Container Platform secrets are created:

```
$ ls <path_to_ccoctl_output_dir>/manifests
```

Example output:

```
openshift-cluster-csi-drivers-alibaba-disk-credentials-credentials.yaml
openshift-image-registry-installer-cloud-credentials-credentials.yaml
openshift-ingress-operator-cloud-credentials-credentials.yaml
openshift-machine-api-alibabacloud-credentials-credentials.yaml
```

You can verify that the RAM users and policies are created by querying Alibaba Cloud. For more information, refer to Alibaba Cloud documentation on listing RAM users and policies.

5. Copy the generated credential files to the target manifests directory:

```
$ cp ./<path_to_ccoctl_output_dir>/manifests/*credentials.yaml
./<path_to_installation>dir>/manifests/
```

where:

<path_to_ccoctl_output_dir>

Specifies the directory created by the **ccoctl alibabacloud create-ram-users** command.

<path_to_installation_dir>

Specifies the directory in which the installation program creates files.

4.3.8. Deploying the cluster

You can install OpenShift Container Platform on a compatible cloud platform.

IMPORTANT

You can run the **create cluster** command of the installation program only once, during initial installation.

Prerequisites

- Configure an account with the cloud platform that hosts your cluster.
- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.

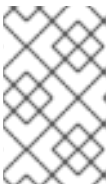
Procedure

- Change to the directory that contains the installation program and initialize the cluster deployment:

```
$ ./openshift-install create cluster --dir <installation_directory> \ 1
    --log-level=info 2
```

1 For **<installation_directory>**, specify the location of your customized **./install-config.yaml** file.

2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.



NOTE

If the cloud provider account that you configured on your host does not have sufficient permissions to deploy the cluster, the installation process stops, and the missing permissions are displayed.

Verification

When the cluster deployment completes successfully:

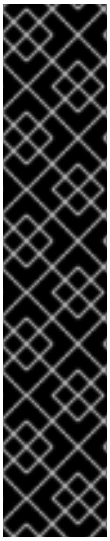
- The terminal displays directions for accessing your cluster, including a link to the web console and credentials for the **kubeadmin** user.
- Credential information also outputs to **<installation_directory>/.openshift_install.log**.

IMPORTANT

Do not delete the installation program or the files that the installation program creates. Both are required to delete the cluster.

Example output

```
...
INFO Install complete!
INFO To access the cluster as the system:admin user when using 'oc', run 'export
KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
INFO Access the OpenShift web-console here: https://console-openshift-
console.apps.mycluster.example.com
INFO Login to the console with user: "kubeadmin", and password: "password"
INFO Time elapsed: 36m22s
```

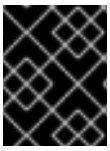


IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

4.3.9. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.



IMPORTANT

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.11. Download and install the new version of **oc**.

Installing the OpenShift CLI on Linux

You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the architecture in the **Product Variant** drop-down menu.
3. Select the appropriate version in the **Version** drop-down menu.

4. Click **Download Now** next to the **OpenShift v4.11 Linux Client** entry and save the file.
5. Unpack the archive:

```
$ tar xvf <file>
```

6. Place the **oc** binary in a directory that is on your **PATH**.
   To check your **PATH**, execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.
   To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
C:\> oc <command>
```

Installing the OpenShift CLI on macOS

You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 macOS Client** entry and save the file.

NOTE

For macOS arm64, choose the **OpenShift v4.11 macOS arm64 Client**entry.

4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your PATH.
   To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

4.3.10. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

Example output

```
system:admin
```

4.3.11. Logging in to the cluster by using the web console

The **kubeadmin** user exists by default after an OpenShift Container Platform installation. You can log in to your cluster as the **kubeadmin** user by using the OpenShift Container Platform web console.

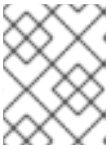
Prerequisites

- You have access to the installation host.
- You completed a cluster installation and all cluster Operators are available.

Procedure

1. Obtain the password for the **kubeadmin** user from the **kubeadmin-password** file on the installation host:

```
$ cat <installation_directory>/auth/kubeadmin-password
```

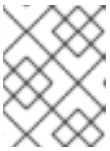


NOTE

Alternatively, you can obtain the **kubeadmin** password from the **<installation_directory>/.openshift_install.log** log file on the installation host.

2. List the OpenShift Container Platform web console route:

```
$ oc get routes -n openshift-console | grep 'console-openshift'
```



NOTE

Alternatively, you can obtain the OpenShift Container Platform route from the **<installation_directory>/.openshift_install.log** log file on the installation host.

Example output

```
console     console-openshift-console.apps.<cluster_name>.<base_domain>          console
https   reencrypt/Redirect   None
```

3. Navigate to the route detailed in the output of the preceding command in a web browser and log in as the **kubeadmin** user.

4.3.12. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.11, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to OpenShift Cluster Manager Hybrid Cloud Console.

After you confirm that your OpenShift Cluster Manager Hybrid Cloud Console inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, use subscription watch to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

Additional resources

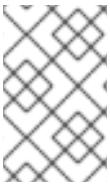
- See Accessing the web console for more details about accessing and understanding the OpenShift Container Platform web console.
- See About remote health monitoring for more information about the Telemetry service

4.3.13. Next steps

- Validating an installation.
- Customize your cluster.
- If necessary, you can opt out of remote health reporting .

4.4. INSTALLING A CLUSTER ON ALIBABA CLOUD WITH CUSTOMIZATIONS

In OpenShift Container Platform version 4.11, you can install a customized cluster on infrastructure that the installation program provisions on Alibaba Cloud. To customize the installation, you modify parameters in the **install-config.yaml** file before you install the cluster.



NOTE

The scope of the OpenShift Container Platform installation configurations is intentionally narrow. It is designed for simplicity and ensured success. You can complete many more OpenShift Container Platform configuration tasks after an installation completes.

IMPORTANT

Alibaba Cloud on OpenShift Container Platform is a Technology Preview feature only. Technology Preview features are not supported with Red Hat production service level agreements (SLAs) and might not be functionally complete. Red Hat does not recommend using them in production. These features provide early access to upcoming product features, enabling customers to test functionality and provide feedback during the development process.

For more information about the support scope of Red Hat Technology Preview features, see Technology Preview Features Support Scope .

4.4.1. Prerequisites

- You reviewed details about the OpenShift Container Platform installation and update processes.
- You read the documentation on selecting a cluster installation method and preparing it for users.
- You registered your domain.
- If you use a firewall, you configured it to allow the sites that your cluster requires access to.
- If the cloud Resource Access Management (RAM) APIs are not accessible in your environment, or if you do not want to store an administrator-level credential secret in the **kube-system** namespace, you can manually create and maintain Resource Access Management (RAM) credentials.

4.4.2. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.11, you require access to the internet to install your cluster.

You must have internet access to:

- Access OpenShift Cluster Manager Hybrid Cloud Console to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access Quay.io to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.

IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

4.4.3. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the **~/.ssh/authorized_keys** list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The **./openshift-install gather** command also requires the SSH public key to be in place on the cluster nodes.

IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.

NOTE

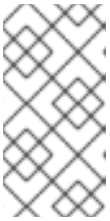
You must use a local key, not one that you configured with platform-specific approaches such as AWS key pairs.

Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N '' -f <path>/<file_name>
```
(1)

1 Specify the path and file name, such as ~/**.ssh/id_ed25519**, of the new SSH key. If you have an existing key pair, ensure your public key is in the your ~/**.ssh** directory.



NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS validated or Modules In Process cryptographic libraries on the **x86_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the ~/**.ssh/id_ed25519.pub** public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the **./openshift-install gather** command.

NOTE

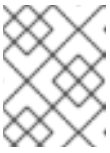
On some distributions, default SSH private key identities such as ~/**.ssh/id_rsa** and ~/**.ssh/id_dsa** are managed automatically.

a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

Example output

```
Agent pid 31874
```



NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

1 Specify the path and file name for your SSH private key, such as ~/**.ssh/id_ed25519**

Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

4.4.4. Obtaining the installation program

Before you install OpenShift Container Platform, download the installation file on a local computer.

Prerequisites

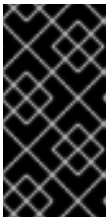
- You have a computer that runs Linux or macOS, with 500 MB of local disk space.

Procedure

1. Access the Infrastructure Provider page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program that corresponds with your host operating system and architecture, and place the file in the directory where you will store the installation configuration files.

IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.



IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation pull secret from the Red Hat OpenShift Cluster Manager . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

4.4.4.1. Creating the installation configuration file

You can customize the OpenShift Container Platform cluster you install on Alibaba Cloud.

Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.
- Obtain service principal permissions at the subscription level.

Procedure

1. Create the **install-config.yaml** file.
   a. Change to the directory that contains the installation program and run the following command:

```
$ ./openshift-install create install-config --dir <installation_directory> 1
```

   1 For **<installation_directory>**, specify the directory name to store the files that the installation program creates.

   When specifying the directory:

   - Verify that the directory has the **execute** permission. This permission is required to run Terraform binaries under the installation directory.
   - Use an empty directory. Some installation assets, such as bootstrap X.509 certificates, have short expiration intervals, therefore you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

   b. At the prompts, provide the configuration details for your cloud:
      i. Optional: Select an SSH key to use to access your cluster machines.

NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

      ii. Select **alibabacloud** as the platform to target.
      iii. Select the region to deploy the cluster to.
      iv. Select the base domain to deploy the cluster to. The base domain corresponds to the public DNS zone that you created for your cluster.
      v. Provide a descriptive name for your cluster.
      vi. Paste the pull secret from the Red Hat OpenShift Cluster Manager .

2. Installing the cluster into Alibaba Cloud requires that the Cloud Credential Operator (CCO) operate in manual mode. Modify the **install-config.yaml** file to set the **credentialsMode** parameter to **Manual**:

Example install-config.yaml configuration file with credentialsMode set to Manual

```
apiVersion: v1
baseDomain: cluster1.example.com
credentialsMode: Manual 1
compute:
- architecture: amd64
  hyperthreading: Enabled
 ...
```

1 Add this line to set the **credentialsMode** to **Manual**.

3. Modify the **install-config.yaml** file. You can find more information about the available parameters in the "Installation configuration parameters" section.

4. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.

IMPORTANT

The **install-config.yaml** file is consumed during the installation process. If you want to reuse the file, you must back it up now.

4.4.4.2. Generating the required installation manifests

You must generate the Kubernetes manifest and Ignition config files that the cluster needs to configure the machines.

Procedure

1. Generate the manifests by running the following command from the directory that contains the installation program:

```
$ openshift-install create manifests --dir <installation_directory>
```

where:

<installation_directory>

Specifies the directory in which the installation program creates files.

4.4.4.3. Creating credentials for OpenShift Container Platform components with the ccoctl tool

You can use the OpenShift Container Platform Cloud Credential Operator (CCO) utility to automate the creation of Alibaba Cloud RAM users and policies for each in-cluster component.

NOTE

By default, **ccoctl** creates objects in the directory in which the commands are run. To create the objects in a different directory, use the **--output-dir** flag. This procedure uses **<path_to_ccoctl_output_dir>** to refer to this directory.

Prerequisites

You must have:

- Extracted and prepared the **ccoctl** binary.
- Created a RAM user with sufficient permission to create the OpenShift Container Platform cluster.
- Added the AccessKeyID (**access_key_id**) and AccessKeySecret (**access_key_secret**) of that RAM user into the **~/.alibabacloud/credentials** file on your local computer.

Procedure

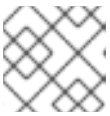
1. Set the **$RELEASE_IMAGE** variable by running the following command:

```
$ RELEASE_IMAGE=$(./openshift-install version | awk '/release image/ {print $3}')
```

2. Extract the list of **CredentialsRequest** objects from the OpenShift Container Platform release image by running the following command:

```
$ oc adm release extract \
--credentials-requests \
--cloud=alibabacloud \
--to=<path_to_directory_with_list_of_credentials_requests>/credrequests \ 1
$RELEASE_IMAGE
```

1. **credrequests** is the directory where the list of **CredentialsRequest** objects is stored. This command creates the directory if it does not exist.



NOTE

This command can take a few moments to run.

3. If your cluster uses cluster capabilities to disable one or more optional components, delete the **CredentialsRequest** custom resources for any disabled components.

Example credrequests directory contents for OpenShift Container Platform 4.12 on Alibaba Cloud

```
0000_30_machine-api-operator_00_credentials-request.yaml 1
0000_50_cluster-image-registry-operator_01-registry-credentials-request-alibaba.yaml 2
0000_50_cluster-ingress-operator_00-ingress-credentials-request.yaml 3
0000_50_cluster-storage-operator_03_credentials_request_alibaba.yaml 4
```

1. The Machine API Operator CR is required.
2. The Image Registry Operator CR is required.
3. The Ingress Operator CR is required.
4. The Storage Operator CR is an optional component and might be disabled in your cluster.

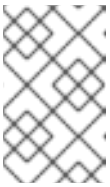
4. Use the **ccoctl** tool to process all **CredentialsRequest** objects in the **credrequests** directory:

a. Run the following command to use the tool:

```
$ ccoctl alibabacloud create-ram-users \
--name <name> \
--region=<alibaba_region> \
--credentials-requests-dir=
<path_to_directory_with_list_of_credentials_requests>/credrequests \
--output-dir=<path_to_ccoctl_output_dir>
```

where:

- **<name>** is the name used to tag any cloud resources that are created for tracking.
- **<alibaba_region>** is the Alibaba Cloud region in which cloud resources will be created.
- **<path_to_directory_with_list_of_credentials_requests>/credrequests** is the directory containing the files for the component **CredentialsRequest** objects.
- **<path_to_ccoctl_output_dir>** is the directory where the generated component credentials secrets will be placed.



NOTE

If your cluster uses Technology Preview features that are enabled by the **TechPreviewNoUpgrade** feature set, you must include the **--enable-tech-preview** parameter.

Example output

```
2022/02/11 16:18:26 Created RAM User: user1-alicloud-openshift-machine-api-
alibabacloud-credentials
2022/02/11 16:18:27 Ready for creating new ram policy user1-alicloud-openshift-
machine-api-alibabacloud-credentials-policy-policy
2022/02/11 16:18:27 RAM policy user1-alicloud-openshift-machine-api-alibabacloud-
credentials-policy-policy has created
2022/02/11 16:18:28 Policy user1-alicloud-openshift-machine-api-alibabacloud-
credentials-policy-policy has attached on user user1-alicloud-openshift-machine-api-
alibabacloud-credentials
2022/02/11 16:18:29 Created access keys for RAM User: user1-alicloud-openshift-
machine-api-alibabacloud-credentials
2022/02/11 16:18:29 Saved credentials configuration to: user1-
alicloud/manifests/openshift-machine-api-alibabacloud-credentials-credentials.yaml
...
```

NOTE

A RAM user can have up to two AccessKeys at the same time. If you run **ccoctl alibabacloud create-ram-users** more than twice, the previous generated manifests secret becomes stale and you must reapply the newly generated secrets.

b. Verify that the OpenShift Container Platform secrets are created:

```
$ ls <path_to_ccoctl_output_dir>/manifests
```

-

Example output:

```
openshift-cluster-csi-drivers-alibaba-disk-credentials-credentials.yaml
openshift-image-registry-installer-cloud-credentials-credentials.yaml
openshift-ingress-operator-cloud-credentials-credentials.yaml
openshift-machine-api-alibabacloud-credentials-credentials.yaml
```

You can verify that the RAM users and policies are created by querying Alibaba Cloud. For more information, refer to Alibaba Cloud documentation on listing RAM users and policies.

5. Copy the generated credential files to the target manifests directory:

```
$ cp ./<path_to_ccoctl_output_dir>/manifests/*credentials.yaml
./<path_to_installation>dir>/manifests/
```

where:

<path_to_ccoctl_output_dir>
Specifies the directory created by the **ccoctl alibabacloud create-ram-users** command.

<path_to_installation_dir>
Specifies the directory in which the installation program creates files.

4.4.4.4. Installation configuration parameters

Before you deploy an OpenShift Container Platform cluster, you provide parameter values to describe your account on the cloud platform that hosts your cluster and optionally customize your cluster's platform. When you create the **install-config.yaml** installation configuration file, you provide values for the required parameters through the command line. If you customize your cluster, you can modify the **install-config.yaml** file to provide more details about the platform.

NOTE

After installation, you cannot modify these parameters in the **install-config.yaml** file.

4.4.4.4.1. Required configuration parameters

Required installation configuration parameters are described in the following table:

Table 4.1. Required parameters

Parameter	Description	Values
apiVersion	The API version for the **install-config.yaml** content. The current version is **v1**. The installer may also support older API versions.	String

Parameter	Description	Values
baseDomain	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the **baseDomain** and **metadata.name** parameter values that uses the **<metadata.name>.<baseDomain>** format.	A fully-qualified domain or subdomain name, such as **example.com**.
metadata	Kubernetes resource **ObjectMeta**, from which only the **name** parameter is consumed.	Object
metadata.name	The name of the cluster. DNS records for the cluster are all subdomains of **{{.metadata.name}}.{{.baseDomain}}**.	String of lowercase letters, hyphens (**-**), and periods (**.**), such as **dev**.
platform	The configuration for the specific platform upon which to perform the installation: **alibabacloud**, **aws**, **baremetal**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**. For additional information about **platform.<platform>** parameters, consult the table for your specific platform that follows.	Object

Parameter	Description	Values
pullSecret	Get a pull secret from the Red Hat OpenShift Cluster Manager to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	<pre>{ "auths":{ "cloud.openshift.com":{ "auth":"b3Blb=", "email":"you@example.com" }, "quay.io":{ "auth":"b3Blb=", "email":"you@example.com" } } }</pre>

4.4.4.4.2. Network configuration parameters

You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

Only IPv4 addresses are supported.

NOTE

Globalnet is not supported with Red Hat OpenShift Data Foundation disaster recovery solutions. For regional disaster recovery scenarios, ensure that you use a nonoverlapping range of private IP addresses for the cluster and service networks in each cluster.

Table 4.2. Network parameters

Parameter	Description	Values
networking	The configuration for the cluster network.	Object  **NOTE** You cannot modify parameters specified by the **networking** object after installation.

Parameter	Description	Values
networking.networkType	The cluster network provider Container Network Interface (CNI) cluster network provider to install.	Either **OpenShiftSDN** or **OVNKubernetes**. **OpenShiftSDN** is a CNI provider for all-Linux networks. **OVNKubernetes** is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is **OpenShiftSDN**.
networking.clusterNetwork	The IP address blocks for pods. The default value is **10.128.0.0/14** with a host prefix of **/23**. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: `networking:` `  clusterNetwork:` `  - cidr: 10.128.0.0/14` `  hostPrefix: 23`
networking.clusterNetwork.cidr	Required if you use **networking.clusterNetwork**. An IP address block. An IPv4 network.	An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between **0** and **32**.
networking.clusterNetwork.hostPrefix	The subnet prefix length to assign to each individual node. For example, if **hostPrefix** is set to **23** then each node is assigned a **/23** subnet out of the given **cidr**. A **hostPrefix** value of **23** provides 510 (2^(32 - 23) - 2) pod IP addresses.	A subnet prefix. The default value is **23**.
networking.serviceNetwork	The IP address block for services. The default value is **172.30.0.0/16**. The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.	An array with an IP address block in CIDR format. For example: `networking:` `  serviceNetwork:` `  - 172.30.0.0/16`
networking.machineNetwork	The IP address blocks for machines. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: `networking:` `  machineNetwork:` `  - cidr: 10.0.0.0/16`

Parameter	Description	Values
networking.machineNetwork.cidr	Required if you use **networking.machineNetwork**. An IP address block. The default value is **10.0.0.0/16** for all platforms other than libvirt. For libvirt, the default value is **192.168.126.0/24**.	An IP network block in CIDR notation. For example, **10.0.0.0/16**.  **NOTE** Set the **networking.machineNetwork** to match the CIDR that the preferred NIC resides in.

4.4.4.4.3. Optional configuration parameters

Optional installation configuration parameters are described in the following table:

Table 4.3. Optional parameters

Parameter	Description	Values
additionalTrustBundle	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String
capabilities	Controls the installation of optional core cluster components. You can reduce the footprint of your OpenShift Container Platform cluster by disabling optional components.	String array
capabilities.baselineCapabilitySet	Selects an initial set of optional capabilities to enable. Valid values are **None**, **v4.11** and **vCurrent**. **v4.11** enables the **baremetal** Operator, the **marketplace** Operator, and the **openshift-samples** content. **vCurrent** installs the recommended set of capabilities for the current version of OpenShift Container Platform. The default value is **vCurrent**.	String

Parameter	Description	Values
capabilities.additionalEnabledCapabilities	Extends the set of optional capabilities beyond what you specify in **baselineCapabilitySet**. Valid values are **baremetal**, **marketplace** and **openshift-samples**. You may specify multiple capabilities in this parameter.	String array
cgroupsV2	Enables Linux control groups version 2 (cgroups v2) on specific nodes in your cluster. The OpenShift Container Platform process for enabling cgroups v2 disables all cgroup version 1 controllers and hierarchies. The OpenShift Container Platform cgroups version 2 feature is in Developer Preview and is not supported by Red Hat at this time.	**true**
compute	The configuration for the machines that comprise the compute nodes.	Array of **MachinePool** objects.
compute.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** (the default).	String
compute.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  IMPORTANT If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
compute.name	Required if you use **compute**. The name of the machine pool.	**worker**

Parameter	Description	Values
compute.platform	Required if you use **compute**. Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the **controlPlane.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
compute.replicas	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to **2**. The default value is **3**.
controlPlane	The configuration for the machines that comprise the control plane.	Array of **MachinePool** objects.
controlPlane.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** (the default).	String
controlPlane.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  IMPORTANT If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
controlPlane.name	Required if you use **controlPlane**. The name of the machine pool.	**master**

Parameter	Description	Values
controlPlane.platform	Required if you use **controlPlane**. Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the **compute.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
controlPlane.replicas	The number of control plane machines to provision.	The only supported value is **3**, which is the default value.
credentialsMode	The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported.  **NOTE** Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the *Cloud Credential Operator* entry in the *Cluster Operators reference* content.  **NOTE** If your AWS account has service control policies (SCP) enabled, you must configure the **credentialsMode** parameter to **Mint**, **Passthrough** or **Manual**.	**Mint**, **Passthrough**, **Manual** or an empty string (**""**).

Parameter	Description	Values
fips	Enable or disable FIPS mode. The default is **false** (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.  **IMPORTANT** To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.  **NOTE** If you are using Azure File storage, you cannot enable FIPS mode.	**false** or **true**
imageContentSources	Sources and repositories for the release-image content.	Array of objects. Includes a **source** and, optionally, **mirrors**, as described in the following rows of this table.
imageContentSources.source	Required if you use **imageContentSources**. Specify the repository that users refer to, for example, in image pull specifications.	String

Parameter	Description	Values
imageContentSources.mirrors	Specify one or more repositories that may also contain the same images.	Array of strings
publish	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	**Internal** or **External**. The default value is **External**. Setting this field to **Internal** is not supported on non-cloud platforms and IBM Cloud VPC.  IMPORTANT If the value of the field is set to **Internal**, the cluster will become non-functional. For more information, refer to BZ#1953035.
sshKey	The SSH key to authenticate access to your cluster machines.  NOTE For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.	For example, **sshKey: ssh-ed25519 AAAA..**.

4.4.4.4.4. Additional Alibaba Cloud configuration parameters

Additional Alibaba Cloud configuration parameters are described in the following table. The **alibabacloud** parameters are the configuration used when installing on Alibaba Cloud. The **defaultMachinePlatform** parameters are the default configuration used when installing on Alibaba Cloud for machine pools that do not define their own platform configuration.

These parameters apply to both compute machines and control plane machines where specified.

NOTE

If defined, the parameters **compute.platform.alibabacloud** and **controlPlane.platform.alibabacloud** will overwrite **platform.alibabacloud.defaultMachinePlatform** settings for compute machines and control plane machines respectively.

Table 4.4. Optional Alibaba Cloud parameters

Parameter	Description	Values
compute.platform.alibabacloud.imageID	The imageID used to create the ECS instance. ImageID must belong to the same region as the cluster.	String.
compute.platform.alibabacloud.instanceType	InstanceType defines the ECS instance type. Example: **ecs.g6.large**	String.
compute.platform.alibabacloud.systemDiskCategory	Defines the category of the system disk. Examples: **cloud_efficiency**,**cloud_essd**	String.
compute.platform.alibabacloud.systemDisksize	Defines the size of the system disk in gibibytes (GiB).	Integer.
compute.platform.alibabacloud.zones	The list of availability zones that can be used. Examples: **cn-hangzhou-h**, **cn-hangzhou-j**	String list.
controlPlane.platform.alibabacloud.imageID	The imageID used to create the ECS instance. ImageID must belong to the same region as the cluster.	String.
controlPlane.platform.alibabacloud.instanceType	InstanceType defines the ECS instance type. Example: **ecs.g6.xlarge**	String.
controlPlane.platform.alibabacloud.systemDiskCategory	Defines the category of the system disk. Examples: **cloud_efficiency**,**cloud_essd**	String.
controlPlane.platform.alibabacloud.systemDisksize	Defines the size of the system disk in gibibytes (GiB).	Integer.
controlPlane.platform.alibabacloud.zones	The list of availability zones that can be used. Examples: **cn-hangzhou-h**, **cn-hangzhou-j**	String list.

Parameter	Description	Values
platform.alibabacloud.region	Required.The Alibaba Cloud region where the cluster will be created.	String.
platform.alibabacloud.resourceGroupID	The ID of an already existing resource group where the cluster will be installed. If empty, the installer will create a new resource group for the cluster.	String.
platform.alibabacloud.tags	Additional keys and values to apply to all Alibaba Cloud resources created for the cluster.	Object.
platform.alibabacloud.vpcID	The ID of an already existing VPC where the cluster should be installed. If empty, the installer will create a new VPC for the cluster.	String.
platform.alibabacloud.vswitchIDs	The ID list of already existing VSwitches where cluster resources will be created. The existing VSwitches can only be used when also using existing VPC. If empty, the installer will create new VSwitches for the cluster.	String list.
platform.alibabacloud.defaultMachinePlatform.imageID	For both compute machines and control plane machines, the image ID that should be used to create ECS instance. If set, the image ID should belong to the same region as the cluster.	String.
platform.alibabacloud.defaultMachinePlatform.instanceType	For both compute machines and control plane machines, the ECS instance type used to create the ECS instance. Example: **ecs.g6.xlarge**	String.

Parameter	Description	Values
platform.alibabacloud.defaultMachinePlatform.systemDiskCategory	For both compute machines and control plane machines, the category of the system disk. Examples: **cloud_efficiency**, **cloud_essd**.	String, for example "", **cloud_efficiency**, **cloud_essd**.
platform.alibabacloud.defaultMachinePlatform.systemDiskSize	For both compute machines and control plane machines, the size of the system disk in gibibytes (GiB). The minimum is **120**.	Integer.
platform.alibabacloud.defaultMachinePlatform.zones	For both compute machines and control plane machines, the list of availability zones that can be used. Examples: **cn-hangzhou-h**, **cn-hangzhou-j**	String list.
platform.alibabacloud.privateZoneID	The ID of an existing private zone into which to add DNS records for the cluster's internal API. An existing private zone can only be used when also using existing VPC. The private zone must be associated with the VPC containing the subnets. Leave the private zone unset to have the installer create the private zone on your behalf.	String.

4.4.4.5. Sample customized install-config.yaml file for Alibaba Cloud

You can customize the installation configuration file (**install-config.yaml**) to specify more details about your cluster's platform or modify the values of the required parameters.

```
apiVersion: v1
baseDomain: alicloud-dev.devcluster.openshift.com
credentialsMode: Manual
compute:
- architecture: amd64
  hyperthreading: Enabled
  name: worker
  platform: {}
  replicas: 3
controlPlane:
```

```
  architecture: amd64
  hyperthreading: Enabled
  name: master
  platform: {}
  replicas: 3
metadata:
  creationTimestamp: null
  name: test-cluster 1
 networking:
  clusterNetwork:
  - cidr: 10.128.0.0/14
    hostPrefix: 23
  machineNetwork:
  - cidr: 10.0.0.0/16
  networkType: OpenShiftSDN 2
  serviceNetwork:
  - 172.30.0.0/16
platform:
  alibabacloud:
    defaultMachinePlatform: 3
      instanceType: ecs.g6.xlarge
      systemDiskCategory: cloud_efficiency
      systemDiskSize: 200
    region: ap-southeast-1 4
    resourceGroupID: rg-acfnw6j3hyai 5
    vpcID: vpc-0xifdjerdibmaqvtjob2b
    vswitchIDs: 6
    - vsw-0xi8ycgwc8wv5rhviwdq5
    - vsw-0xiy6v3z2tedv009b4pz2
publish: External
pullSecret: '{"auths": {"cloud.openshift.com": {"auth": ... }' 7
sshKey: |
  ssh-rsa AAAA... 8
```

1 Required. The installation program prompts you for a cluster name.

2 The cluster network plugin to install. The supported values are **OVNKubernetes** and **OpenShiftSDN**. The default value is **OVNKubernetes**.

3 Optional. Specify parameters for machine pools that do not define their own platform configuration.

4 Required. The installation program prompts you for the region to deploy the cluster to.

5 Optional. Specify an existing resource group where the cluster should be installed.

7 Required. The installation program prompts you for the pull secret.

8 Optional. The installation program prompts you for the SSH key value that you use to access the machines in your cluster.

6 Optional. These are example vswitchID values.

4.4.4.6. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.

NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

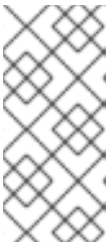
```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
```

1. A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
2. A proxy URL to use for creating HTTPS connections outside the cluster.
3. A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use ***** to bypass the proxy for all destinations.
4. If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace that contains one or more additional CA certificates that are required for proxying HTTPS connections. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges these contents with the Red Hat Enterprise Linux CoreOS (RHCOS) trust bundle, and this config map is referenced in the **trustedCA** field of the **Proxy** object. The **additionalTrustBundle** field is required unless

the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.

NOTE

The installation program does not support the proxy **readinessEndpoints** field.



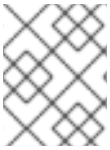
NOTE

If the installer times out, restart and then complete the deployment by using the **wait-for** command of the installer. For example:

```
$ ./openshift-install wait-for install-complete --log-level debug
```

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.



NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

4.4.5. Deploying the cluster

You can install OpenShift Container Platform on a compatible cloud platform.

IMPORTANT

You can run the **create cluster** command of the installation program only once, during initial installation.

Prerequisites

- Configure an account with the cloud platform that hosts your cluster.
- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.

Procedure

- Change to the directory that contains the installation program and initialize the cluster deployment:

```
$ ./openshift-install create cluster --dir <installation_directory> \ 1
    --log-level=info 2
```

1 For **<installation_directory>**, specify the location of your customized **./install-config.yaml** file.

2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

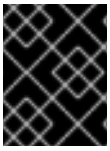
NOTE

If the cloud provider account that you configured on your host does not have sufficient permissions to deploy the cluster, the installation process stops, and the missing permissions are displayed.

Verification

When the cluster deployment completes successfully:

- The terminal displays directions for accessing your cluster, including a link to the web console and credentials for the **kubeadmin** user.
- Credential information also outputs to **<installation_directory>/.openshift_install.log**.



IMPORTANT

Do not delete the installation program or the files that the installation program creates. Both are required to delete the cluster.

Example output

```
...
INFO Install complete!
INFO To access the cluster as the system:admin user when using 'oc', run 'export
KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
INFO Access the OpenShift web-console here: https://console-openshift-
console.apps.mycluster.example.com
INFO Login to the console with user: "kubeadmin", and password: "password"
INFO Time elapsed: 36m22s
```

IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

4.4.6. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.

IMPORTANT

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.11. Download and install the new version of **oc**.

Installing the OpenShift CLI on Linux

You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the architecture in the **Product Variant** drop-down menu.
3. Select the appropriate version in the **Version** drop-down menu.
4. Click **Download Now** next to the **OpenShift v4.11 Linux Client** entry and save the file.
5. Unpack the archive:

```
$ tar xvf <file>
```

6. Place the **oc** binary in a directory that is on your **PATH**.
   To check your **PATH**, execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.
   To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
C:\> oc <command>
```

Installing the OpenShift CLI on macOS
You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 macOS Client** entry and save the file.

NOTE

For macOS arm64, choose the **OpenShift v4.11 macOS arm64 Client** entry.

4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your PATH.
   To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

4.4.7. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

-

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

Example output

```
system:admin
```

4.4.8. Logging in to the cluster by using the web console

The **kubeadmin** user exists by default after an OpenShift Container Platform installation. You can log in to your cluster as the **kubeadmin** user by using the OpenShift Container Platform web console.

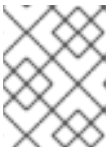
Prerequisites

- You have access to the installation host.
- You completed a cluster installation and all cluster Operators are available.

Procedure

1. Obtain the password for the **kubeadmin** user from the **kubeadmin-password** file on the installation host:

```
$ cat <installation_directory>/auth/kubeadmin-password
```



NOTE

Alternatively, you can obtain the **kubeadmin** password from the **<installation_directory>/.openshift_install.log** log file on the installation host.

2. List the OpenShift Container Platform web console route:

```
$ oc get routes -n openshift-console | grep 'console-openshift'
```

NOTE

Alternatively, you can obtain the OpenShift Container Platform route from the **<installation_directory>/.openshift_install.log** log file on the installation host.

Example output

```
console     console-openshift-console.apps.<cluster_name>.<base_domain>           console
https   reencrypt/Redirect   None
```

3. Navigate to the route detailed in the output of the preceding command in a web browser and log in as the **kubeadmin** user.

4.4.9. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.11, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to OpenShift Cluster Manager Hybrid Cloud Console.

After you confirm that your OpenShift Cluster Manager Hybrid Cloud Console inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, use subscription watch to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

Additional resources

- See About remote health monitoring for more information about the Telemetry service.
- See Accessing the web console for more details about accessing and understanding the OpenShift Container Platform web console
- See Accessing the web console for more details about accessing and understanding the OpenShift Container Platform web console.

4.4.10. Next steps

- Validating an installation.
- Customize your cluster.
- If necessary, you can opt out of remote health reporting .

4.5. INSTALLING A CLUSTER ON ALIBABA CLOUD WITH NETWORK CUSTOMIZATIONS

In OpenShift Container Platform 4.11, you can install a cluster on Alibaba Cloud with customized network configuration options. By customizing your network configuration, your cluster can coexist with existing IP address allocations in your environment and integrate with existing MTU and VXLAN configurations.

You must set most of the network configuration parameters during installation, and you can modify only **kubeProxy** configuration parameters in a running cluster.

IMPORTANT

Alibaba Cloud on OpenShift Container Platform is a Technology Preview feature only. Technology Preview features are not supported with Red Hat production service level agreements (SLAs) and might not be functionally complete. Red Hat does not recommend using them in production. These features provide early access to upcoming product features, enabling customers to test functionality and provide feedback during the development process.

For more information about the support scope of Red Hat Technology Preview features, see Technology Preview Features Support Scope .

4.5.1. Prerequisites

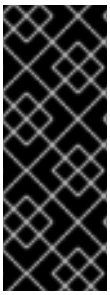
- You reviewed details about the OpenShift Container Platform installation and update processes.
- You read the documentation on selecting a cluster installation method and preparing it for users.
- You registered your domain.
- If you use a firewall, you configured it to allow the sites that your cluster requires access to.
- If the cloud Resource Access Management (RAM) APIs are not accessible in your environment, or if you do not want to store an administrator-level credential secret in the **kube-system** namespace, you can manually create and maintain Resource Access Management (RAM) credentials.

4.5.2. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.11, you require access to the internet to install your cluster.

You must have internet access to:

- Access OpenShift Cluster Manager Hybrid Cloud Console to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access Quay.io to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.



IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

4.5.3. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the **~/.ssh/authorized_keys** list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The **./openshift-install gather** command also requires the SSH public key to be in place on the cluster nodes.

IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.

NOTE

You must use a local key, not one that you configured with platform-specific approaches such as AWS key pairs.

Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N '' -f <path>/<file_name> 1
```

1 Specify the path and file name, such as ~/**.ssh/id_ed25519**, of the new SSH key. If you have an existing key pair, ensure your public key is in the your ~/**.ssh** directory.

NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS validated or Modules In Process cryptographic libraries on the **x86_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the ~/**.ssh/id_ed25519.pub** public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the **./openshift-install gather** command.

NOTE

On some distributions, default SSH private key identities such as ~/**.ssh/id_rsa** and ~/**.ssh/id_dsa** are managed automatically.

a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

Example output

```
Agent pid 31874
```

NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

1 Specify the path and file name for your SSH private key, such as **~/.ssh/id_ed25519**

Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

4.5.4. Obtaining the installation program

Before you install OpenShift Container Platform, download the installation file on a local computer.

Prerequisites

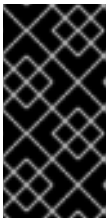
- You have a computer that runs Linux or macOS, with 500 MB of local disk space.

Procedure

1. Access the Infrastructure Provider page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program that corresponds with your host operating system and architecture, and place the file in the directory where you will store the installation configuration files.

IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.



IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation pull secret from the Red Hat OpenShift Cluster Manager . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

4.5.5. Network configuration phases

There are two phases prior to OpenShift Container Platform installation where you can customize the network configuration.

Phase 1

You can customize the following network-related fields in the **install-config.yaml** file before you create the manifest files:

- **networking.networkType**
- **networking.clusterNetwork**
- **networking.serviceNetwork**
- **networking.machineNetwork**
  For more information on these fields, refer to *Installation configuration parameters*.

NOTE

Set the **networking.machineNetwork** to match the CIDR that the preferred NIC resides in.

IMPORTANT

The CIDR range **172.17.0.0/16** is reserved by libVirt. You cannot use this range or any range that overlaps with this range for any networks in your cluster.

Phase 2

After creating the manifest files by running **openshift-install create manifests**, you can define a customized Cluster Network Operator manifest with only the fields you want to modify. You can use the manifest to specify advanced network configuration.

You cannot override the values specified in phase 1 in the **install-config.yaml** file during phase 2. However, you can further customize the cluster network provider during phase 2.

4.5.5.1. Creating the installation configuration file

You can customize the OpenShift Container Platform cluster you install on

Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.
- Obtain service principal permissions at the subscription level.

Procedure

1. Create the **install-config.yaml** file.
   a. Change to the directory that contains the installation program and run the following command:

```
$ ./openshift-install create install-config --dir <installation_directory> 1
```

   1 For **<installation_directory>**, specify the directory name to store the files that the installation program creates.

   When specifying the directory:

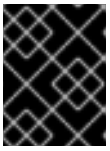
   - Verify that the directory has the **execute** permission. This permission is required to run Terraform binaries under the installation directory.
   - Use an empty directory. Some installation assets, such as bootstrap X.509 certificates, have short expiration intervals, therefore you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

   b. At the prompts, provide the configuration details for your cloud:
      i. Optional: Select an SSH key to use to access your cluster machines.

NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

      ii. Enter a descriptive name for your cluster.
      iii. Paste the pull secret from the Red Hat OpenShift Cluster Manager .
2. Modify the **install-config.yaml** file. You can find more information about the available parameters in the "Installation configuration parameters" section.
3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.



IMPORTANT

The **install-config.yaml** file is consumed during the installation process. If you want to reuse the file, you must back it up now.

4.5.5.2. Generating the required installation manifests

You must generate the Kubernetes manifest and Ignition config files that the cluster needs to configure the machines.

Procedure

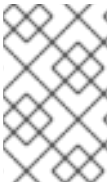
1. Generate the manifests by running the following command from the directory that contains the installation program:

```
$ openshift-install create manifests --dir <installation_directory>
```

where:

<installation_directory>

Specifies the directory in which the installation program creates files.



NOTE

By default, **ccoctl** creates objects in the directory in which the commands are run. To create the objects in a different directory, use the **--output-dir** flag. This procedure uses **<path_to_ccoctl_output_dir>** to refer to this directory.

Prerequisites

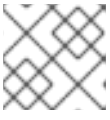
You must have:

- Extracted and prepared the **ccoctl** binary.

Procedure

1. Extract the list of **CredentialsRequest** objects from the OpenShift Container Platform release image by running the following command:

```
<1> `credrequests` is the directory where the list of `CredentialsRequest` objects is stored.
This command creates the directory if it does not exist.
```



NOTE

This command can take a few moments to run.

4.5.5.3. Installation configuration parameters

Before you deploy an OpenShift Container Platform cluster, you provide parameter values to describe your account on the cloud platform that hosts your cluster and optionally customize your cluster's platform. When you create the **install-config.yaml** installation configuration file, you provide values for the required parameters through the command line. If you customize your cluster, you can modify the **install-config.yaml** file to provide more details about the platform.

NOTE

After installation, you cannot modify these parameters in the **install-config.yaml** file.

4.5.5.3.1. Required configuration parameters

Required installation configuration parameters are described in the following table:

Table 4.5. Required parameters

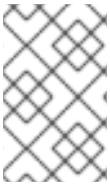
Parameter	Description	Values
apiVersion	The API version for the **install-config.yaml** content. The current version is **v1**. The installer may also support older API versions.	String
baseDomain	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the **baseDomain** and **metadata.name** parameter values that uses the **<metadata.name>.<baseDomain>** format.	A fully-qualified domain or subdomain name, such as **example.com**.
metadata	Kubernetes resource **ObjectMeta**, from which only the **name** parameter is consumed.	Object
metadata.name	The name of the cluster. DNS records for the cluster are all subdomains of **{{.metadata.name}}.{{.baseDomain}}**.	String of lowercase letters, hyphens (**-**), and periods (**.**), such as **dev**.

Parameter	Description	Values
platform	The configuration for the specific platform upon which to perform the installation: **alibabacloud**, **aws**, **baremetal**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**. For additional information about **platform.<platform>** parameters, consult the table for your specific platform that follows.	Object
pullSecret	Get a pull secret from the Red Hat OpenShift Cluster Manager to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	<pre>{ "auths":{ "cloud.openshift.com":{ "auth":"b3Blb=", "email":"you@example.com" }, "quay.io":{ "auth":"b3Blb=", "email":"you@example.com" } } }</pre>

4.5.5.3.2. Network configuration parameters

You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

Only IPv4 addresses are supported.



NOTE

Globalnet is not supported with Red Hat OpenShift Data Foundation disaster recovery solutions. For regional disaster recovery scenarios, ensure that you use a nonoverlapping range of private IP addresses for the cluster and service networks in each cluster.

Table 4.6. Network parameters

Parameter	Description	Values

Parameter	Description	Values
networking	The configuration for the cluster network.	Object  **NOTE** You cannot modify parameters specified by the **networking** object after installation.
networking.networkType	The cluster network provider Container Network Interface (CNI) cluster network provider to install.	Either **OpenShiftSDN** or **OVNKubernetes**. **OpenShiftSDN** is a CNI provider for all-Linux networks. **OVNKubernetes** is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is **OpenShiftSDN**.
networking.clusterNetwork	The IP address blocks for pods. The default value is **10.128.0.0/14** with a host prefix of **/23**. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: `networking:` `  clusterNetwork:` `  - cidr: 10.128.0.0/14` `    hostPrefix: 23`
networking.clusterNetwork.cidr	Required if you use **networking.clusterNetwork**. An IP address block. An IPv4 network.	An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between **0** and **32**.
networking.clusterNetwork.hostPrefix	The subnet prefix length to assign to each individual node. For example, if **hostPrefix** is set to **23** then each node is assigned a **/23** subnet out of the given **cidr**. A **hostPrefix** value of **23** provides 510 (2^(32 - 23) - 2) pod IP addresses.	A subnet prefix. The default value is **23**.
networking.serviceNetwork	The IP address block for services. The default value is **172.30.0.0/16**. The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.	An array with an IP address block in CIDR format. For example: `networking:` `  serviceNetwork:` `  - 172.30.0.0/16`

Parameter	Description	Values
networking.machineNetwork	The IP address blocks for machines. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: networking: machineNetwork: - cidr: 10.0.0.0/16
networking.machineNetwork.cidr	Required if you use **networking.machineNetwork**. An IP address block. The default value is **10.0.0.0/16** for all platforms other than libvirt. For libvirt, the default value is **192.168.126.0/24**.	An IP network block in CIDR notation. For example, **10.0.0.0/16**.  **NOTE** Set the **networking.machineNetwork** to match the CIDR that the preferred NIC resides in.

4.5.5.3.3. Optional configuration parameters

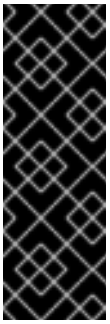
Optional installation configuration parameters are described in the following table:

Table 4.7. Optional parameters

Parameter	Description	Values
additionalTrustBundle	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String
capabilities	Controls the installation of optional core cluster components. You can reduce the footprint of your OpenShift Container Platform cluster by disabling optional components.	String array

Parameter	Description	Values
capabilities.baselineCapabilitySet	Selects an initial set of optional capabilities to enable. Valid values are **None**, **v4.11** and **vCurrent**. **v4.11** enables the **baremetal** Operator, the **marketplace** Operator, and the **openshift-samples** content. **vCurrent** installs the recommended set of capabilities for the current version of OpenShift Container Platform. The default value is **vCurrent**.	String
capabilities.additionalEnabledCapabilities	Extends the set of optional capabilities beyond what you specify in **baselineCapabilitySet**. Valid values are **baremetal**, **marketplace** and **openshift-samples**. You may specify multiple capabilities in this parameter.	String array
cgroupsV2	Enables Linux control groups version 2 (cgroups v2) on specific nodes in your cluster. The OpenShift Container Platform process for enabling cgroups v2 disables all cgroup version 1 controllers and hierarchies. The OpenShift Container Platform cgroups version 2 feature is in Developer Preview and is not supported by Red Hat at this time.	**true**
compute	The configuration for the machines that comprise the compute nodes.	Array of **MachinePool** objects.
compute.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** (the default).	String

Parameter	Description	Values
compute.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  **IMPORTANT** If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
compute.name	Required if you use **compute**. The name of the machine pool.	**worker**
compute.platform	Required if you use **compute**. Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the **controlPlane.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
compute.replicas	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to **2**. The default value is **3**.
controlPlane	The configuration for the machines that comprise the control plane.	Array of **MachinePool** objects.
controlPlane.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** (the default).	String

Parameter	Description	Values
controlPlane.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  **IMPORTANT** If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
controlPlane.name	Required if you use **controlPlane**. The name of the machine pool.	**master**
controlPlane.platform	Required if you use **controlPlane**. Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the **compute.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
controlPlane.replicas	The number of control plane machines to provision.	The only supported value is **3**, which is the default value.

Parameter	Description	Values
credentialsMode	The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported.  **NOTE** Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the *Cloud Credential Operator* entry in the *Cluster Operators reference* content.  **NOTE** If your AWS account has service control policies (SCP) enabled, you must configure the **credentialsMode** parameter to **Mint**, **Passthrough** or **Manual**.	**Mint**, **Passthrough**, **Manual** or an empty string (**""**).
fips	Enable or disable FIPS mode. The default is **false** (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.	**false** or **true**

Parameter	Description	Values
	IMPORTANT  To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.  **NOTE** If you are using Azure File storage, you cannot enable FIPS mode.	
imageContentSources	Sources and repositories for the release-image content.	Array of objects. Includes a **source** and, optionally, **mirrors**, as described in the following rows of this table.
imageContentSources.source	Required if you use **imageContentSources**. Specify the repository that users refer to, for example, in image pull specifications.	String
imageContentSources.mirrors	Specify one or more repositories that may also contain the same images.	Array of strings

Parameter	Description	Values
publish	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	**Internal** or **External**. The default value is **External**. Setting this field to **Internal** is not supported on non-cloud platforms and IBM Cloud VPC.  **IMPORTANT** If the value of the field is set to **Internal**, the cluster will become non-functional. For more information, refer to BZ#1953035.
sshKey	The SSH key to authenticate access to your cluster machines.  **NOTE** For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.	For example, **sshKey: ssh-ed25519 AAAA..**.

4.5.5.4. Sample customized install-config.yaml file for Alibaba Cloud

You can customize the installation configuration file (**install-config.yaml**) to specify more details about your cluster's platform or modify the values of the required parameters.

```
apiVersion: v1
baseDomain: alicloud-dev.devcluster.openshift.com
credentialsMode: Manual
compute:
```

```
- architecture: amd64
  hyperthreading: Enabled
  name: worker
  platform: {}
  replicas: 3
controlPlane:
  architecture: amd64
  hyperthreading: Enabled
  name: master
  platform: {}
  replicas: 3
metadata:
  creationTimestamp: null
  name: test-cluster 1
 networking:
  clusterNetwork:
  - cidr: 10.128.0.0/14
    hostPrefix: 23
  machineNetwork:
  - cidr: 10.0.0.0/16
  networkType: OpenShiftSDN 2
  serviceNetwork:
  - 172.30.0.0/16
platform:
  alibabacloud:
    defaultMachinePlatform: 3
      instanceType: ecs.g6.xlarge
      systemDiskCategory: cloud_efficiency
      systemDiskSize: 200
    region: ap-southeast-1 4
    resourceGroupID: rg-acfnw6j3hyai 5
    vpcID: vpc-0xifdjerdibmaqvtjob2b
    vswitchIDs: 6
    - vsw-0xi8ycgwc8wv5rhviwdq5
    - vsw-0xiy6v3z2tedv009b4pz2
publish: External
pullSecret: '{"auths": {"cloud.openshift.com": {"auth": ... }' 7
sshKey: |
  ssh-rsa AAAA... 8
```

1. Required. The installation program prompts you for a cluster name.
2. The cluster network plugin to install. The supported values are **OVNKubernetes** and **OpenShiftSDN**. The default value is **OVNKubernetes**.
3. Optional. Specify parameters for machine pools that do not define their own platform configuration.
4. Required. The installation program prompts you for the region to deploy the cluster to.
5. Optional. Specify an existing resource group where the cluster should be installed.
7. Required. The installation program prompts you for the pull secret.
8. Optional. The installation program prompts you for the SSH key value that you use to access the

6 Optional. These are example vswitchID values.

4.5.5.5. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.

NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
```

1 A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.

2 A proxy URL to use for creating HTTPS connections outside the cluster.

3 A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use * to bypass the proxy for all destinations.

4 If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace that contains one or more additional CA certificates

NOTE

The installation program does not support the proxy **readinessEndpoints** field.

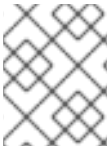
NOTE

If the installer times out, restart and then complete the deployment by using the **wait-for** command of the installer. For example:

```
$ ./openshift-install wait-for install-complete --log-level debug
```

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.



NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

4.5.6. Cluster Network Operator configuration

The configuration for the cluster network is specified as part of the Cluster Network Operator (CNO) configuration and stored in a custom resource (CR) object that is named **cluster**. The CR specifies the fields for the **Network** API in the **operator.openshift.io** API group.

The CNO configuration inherits the following fields during cluster installation from the **Network** API in the **Network.config.openshift.io** API group and these fields cannot be changed:

clusterNetwork

IP address pools from which pod IP addresses are allocated.

serviceNetwork

IP address pool for services.

defaultNetwork.type

Cluster network provider, such as OpenShift SDN or OVN-Kubernetes.

You can specify the cluster network provider configuration for your cluster by setting the fields for the **defaultNetwork** object in the CNO object named **cluster**.

4.5.6.1. Cluster Network Operator configuration object

The fields for the Cluster Network Operator (CNO) are described in the following table:

Table 4.8. Cluster Network Operator configuration object

Field	Type	Description
metadata.name	**string**	The name of the CNO object. This name is always **cluster**.
spec.clusterNetwork	**array**	A list specifying the blocks of IP addresses from which pod IP addresses are allocated and the subnet prefix length assigned to each individual node in the cluster. For example: `spec:` `  clusterNetwork:` `  - cidr: 10.128.0.0/19` `  hostPrefix: 23` `  - cidr: 10.128.32.0/19` `  hostPrefix: 23` You can customize this field only in the **install-config.yaml** file before you create the manifests. The value is read-only in the manifest file.
spec.serviceNetwork	**array**	A block of IP addresses for services. The OpenShift SDN and OVN-Kubernetes Container Network Interface (CNI) network providers support only a single IP address block for the service network. For example: `spec:` `  serviceNetwork:` `  - 172.30.0.0/14` You can customize this field only in the **install-config.yaml** file before you create the manifests. The value is read-only in the manifest file.
spec.defaultNetwork	**object**	Configures the Container Network Interface (CNI) cluster network provider for the cluster network.
spec.kubeProxyConfig	**object**	The fields for this object specify the kube-proxy configuration. If you are using the OVN-Kubernetes cluster network provider, the kube-proxy configuration has no effect.

defaultNetwork object configuration

The values for the **defaultNetwork** object are defined in the following table:

Table 4.9. defaultNetwork object

Field	Type	Description

Field	Type	Description
type	**string**	Either **OpenShiftSDN** or **OVNKubernetes**. The cluster network provider is selected during installation. This value cannot be changed after cluster installation.  **NOTE** OpenShift Container Platform uses the OpenShift SDN Container Network Interface (CNI) cluster network provider by default.
openshiftSDNConfig	**object**	This object is only valid for the OpenShift SDN cluster network provider.
ovnKubernetesConfig	**object**	This object is only valid for the OVN-Kubernetes cluster network provider.

Configuration for the OpenShift SDN CNI cluster network provider
The following table describes the configuration fields for the OpenShift SDN Container Network Interface (CNI) cluster network provider.

Table 4.10. **openshiftSDNConfig** object

Field	Type	Description
mode	**string**	Configures the network isolation mode for OpenShift SDN. The default value is **NetworkPolicy**. The values **Multitenant** and **Subnet** are available for backwards compatibility with OpenShift Container Platform 3.x but are not recommended. This value cannot be changed after cluster installation.

Field	Type	Description
mtu	**integer**	The maximum transmission unit (MTU) for the VXLAN overlay network. This is detected automatically based on the MTU of the primary network interface. You do not normally need to override the detected MTU. If the auto-detected value is not what you expect it to be, confirm that the MTU on the primary network interface on your nodes is correct. You cannot use this option to change the MTU value of the primary network interface on the nodes. If your cluster requires different MTU values for different nodes, you must set this value to **50** less than the lowest MTU value in your cluster. For example, if some nodes in your cluster have an MTU of **9001**, and some have an MTU of**1500**, you must set this value to **1450**. This value cannot be changed after cluster installation.
vxlanPort	**integer**	The port to use for all VXLAN packets. The default value is **4789**. This value cannot be changed after cluster installation. If you are running in a virtualized environment with existing nodes that are part of another VXLAN network, then you might be required to change this. For example, when running an OpenShift SDN overlay on top of VMware NSX-T, you must select an alternate port for the VXLAN, because both SDNs use the same default VXLAN port number. On Amazon Web Services (AWS), you can select an alternate port for the VXLAN between port **9000** and port **9999**.

Example OpenShift SDN configuration

```
defaultNetwork:
  type: OpenShiftSDN
  openshiftSDNConfig:
    mode: NetworkPolicy
    mtu: 1450
    vxlanPort: 4789
```

Configuration for the OVN-Kubernetes CNI cluster network provider

The following table describes the configuration fields for the OVN-Kubernetes CNI cluster network provider.

Table 4.11. ovnKubernetesConfig object

Field	Type	Description

Field	Type	Description
mtu	**integer**	The maximum transmission unit (MTU) for the Geneve (Generic Network Virtualization Encapsulation) overlay network. This is detected automatically based on the MTU of the primary network interface. You do not normally need to override the detected MTU. If the auto-detected value is not what you expect it to be, confirm that the MTU on the primary network interface on your nodes is correct. You cannot use this option to change the MTU value of the primary network interface on the nodes. If your cluster requires different MTU values for different nodes, you must set this value to **100** less than the lowest MTU value in your cluster. For example, if some nodes in your cluster have an MTU of **9001**, and some have an MTU of**1500**, you must set this value to **1400**.
genevePort	**integer**	The port to use for all Geneve packets. The default value is **6081**. This value cannot be changed after cluster installation.
ipsecConfig	**object**	Specify an empty object to enable IPsec encryption.
policyAuditConfig	**object**	Specify a configuration object for customizing network policy audit logging. If unset, the defaults audit log settings are used.
gatewayConfig	**object**	Optional: Specify a configuration object for customizing how egress traffic is sent to the node gateway.  NOTE While migrating egress traffic, you can expect some disruption to workloads and service traffic until the Cluster Network Operator (CNO) successfully rolls out the changes.

Table 4.12. **policyAuditConfig** object

Field	Type	Description
rateLimit	integer	The maximum number of messages to generate every second per node. The default value is **20** messages per second.
maxFileSize	integer	The maximum size for the audit log in bytes. The default value is **50000000** or 50 MB.

Field	Type	Description
destination	string	One of the following additional audit log targets: **libc** The libc **syslog()** function of the journald process on the host. **udp:<host>:<port>** A syslog server. Replace **<host>:<port>** with the host and port of the syslog server. **unix:<file>** A Unix Domain Socket file specified by **<file>**. **null** Do not send the audit logs to any additional target.
syslogFacility	string	The syslog facility, such as **kern**, as defined by RFC5424. The default value is **local0**.

Table 4.13. **gatewayConfig** object

Field	Type	Description
routingViaHost	**boolean**	Set this field to **true** to send egress traffic from pods to the host networking stack. For highly-specialized installations and applications that rely on manually configured routes in the kernel routing table, you might want to route egress traffic to the host networking stack. By default, egress traffic is processed in OVN to exit the cluster and is not affected by specialized routes in the kernel routing table. The default value is **false**. This field has an interaction with the Open vSwitch hardware offloading feature. If you set this field to **true**, you do not receive the performance benefits of the offloading because egress traffic is processed by the host networking stack.

Example OVN-Kubernetes configuration with IPSec enabled

```
defaultNetwork:
  type: OVNKubernetes
  ovnKubernetesConfig:
    mtu: 1400
    genevePort: 6081
    ipsecConfig: {}
```

kubeProxyConfig object configuration
The values for the **kubeProxyConfig** object are defined in the following table:

Table 4.14. **kubeProxyConfig** object

Field	Type	Description
iptablesSyncPeriod	**string**	The refresh period for **iptables** rules. The default value is **30s**. Valid suffixes include **s**, **m**, and **h** and are described in the Go **time** package documentation. NOTE Because of performance improvements introduced in OpenShift Container Platform 4.3 and greater, adjusting the **iptablesSyncPeriod** parameter is no longer necessary.
proxyArguments.iptables-min-sync-period	**array**	The minimum duration before refreshing **iptables** rules. This field ensures that the refresh does not happen too frequently. Valid suffixes include **s**, **m**, and **h** and are described in the Go **time** package. The default value is: `kubeProxyConfig:` `  proxyArguments:` `  iptables-min-sync-period:` `  - 0s`

4.5.7. Specifying advanced network configuration

You can use advanced network configuration for your cluster network provider to integrate your cluster into your existing network environment. You can specify advanced network configuration only before you install the cluster.

IMPORTANT

Customizing your network configuration by modifying the OpenShift Container Platform manifest files created by the installation program is not supported. Applying a manifest file that you create, as in the following procedure, is supported.

Prerequisites

- You have created the **install-config.yaml** file and completed any modifications to it.

Procedure

1. Change to the directory that contains the installation program and create the manifests:

```
$ ./openshift-install create manifests --dir <installation_directory> 1
```

1 **<installation_directory>** specifies the name of the directory that contains the **install-config.yaml** file for your cluster.

2. Create a stub manifest file for the advanced network configuration that is named **cluster-network-03-config.yml** in the **<installation_directory>/manifests/** directory:

```
apiVersion: operator.openshift.io/v1
kind: Network
metadata:
  name: cluster
spec:
```

3. Specify the advanced network configuration for your cluster in the **cluster-network-03-config.yml** file, such as in the following examples:

   Specify a different VXLAN port for the OpenShift SDN network provider

```
apiVersion: operator.openshift.io/v1
kind: Network
metadata:
  name: cluster
spec:
  defaultNetwork:
    openshiftSDNConfig:
      vxlanPort: 4800
```

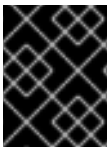
   Enable IPsec for the OVN-Kubernetes network provider

```
apiVersion: operator.openshift.io/v1
kind: Network
metadata:
  name: cluster
spec:
  defaultNetwork:
    ovnKubernetesConfig:
      ipsecConfig: {}
```

4. Optional: Back up the **manifests/cluster-network-03-config.yml** file. The installation program consumes the **manifests/** directory when you create the Ignition config files.

4.5.8. Configuring hybrid networking with OVN-Kubernetes

You can configure your cluster to use hybrid networking with OVN-Kubernetes. This allows a hybrid cluster that supports different node networking configurations. For example, this is necessary to run both Linux and Windows nodes in a cluster.



IMPORTANT

You must configure hybrid networking with OVN-Kubernetes during the installation of your cluster. You cannot switch to hybrid networking after the installation process.

Prerequisites

- You defined **OVNKubernetes** for the **networking.networkType** parameter in the **install-config.yaml** file. See the installation documentation for configuring OpenShift Container Platform network customizations on your chosen cloud provider for more information.

Procedure

1. Change to the directory that contains the installation program and create the manifests:

```
$ ./openshift-install create manifests --dir <installation_directory>
```

where:

<installation_directory>

Specifies the name of the directory that contains the **install-config.yaml** file for your cluster.

2. Create a stub manifest file for the advanced network configuration that is named **cluster-network-03-config.yml** in the **<installation_directory>/manifests/** directory:

```
$ cat <<EOF > <installation_directory>/manifests/cluster-network-03-config.yml
apiVersion: operator.openshift.io/v1
kind: Network
metadata:
  name: cluster
spec:
EOF
```

where:

<installation_directory>

Specifies the directory name that contains the **manifests/** directory for your cluster.

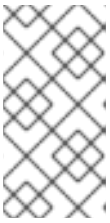
3. Open the **cluster-network-03-config.yml** file in an editor and configure OVN-Kubernetes with hybrid networking, such as in the following example:

Specify a hybrid networking configuration

```
apiVersion: operator.openshift.io/v1
kind: Network
metadata:
  name: cluster
spec:
  defaultNetwork:
    ovnKubernetesConfig:
      hybridOverlayConfig:
        hybridClusterNetwork: 1
        - cidr: 10.132.0.0/14
          hostPrefix: 23
        hybridOverlayVXLANPort: 9898 2
```

1 Specify the CIDR configuration used for nodes on the additional overlay network. The **hybridClusterNetwork** CIDR cannot overlap with the **clusterNetwork** CIDR.

2 Specify a custom VXLAN port for the additional overlay network. This is required for running Windows nodes in a cluster installed on vSphere, and must not be configured for any other cloud provider. The custom port can be any open port excluding the default **4789** port. For more information on this requirement, see the Microsoft documentation on Pod-to-pod connectivity between hosts is broken.



NOTE

Windows Server Long-Term Servicing Channel (LTSC): Windows Server 2019 is not supported on clusters with a custom **hybridOverlayVXLANPort** value because this Windows server version does not support selecting a custom VXLAN port.

4. Save the **cluster-network-03-config.yml** file and quit the text editor.

5. Optional: Back up the **manifests/cluster-network-03-config.yml** file. The installation program deletes the **manifests/** directory when creating the cluster.

4.5.9. Deploying the cluster

You can install OpenShift Container Platform on a compatible cloud platform.

IMPORTANT

You can run the **create cluster** command of the installation program only once, during initial installation.

Prerequisites

- Configure an account with the cloud platform that hosts your cluster.
- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.

Procedure

- Change to the directory that contains the installation program and initialize the cluster deployment:

```
$ ./openshift-install create cluster --dir <installation_directory> \ 1
    --log-level=info 2
```

1 For **<installation_directory>**, specify the location of your customized **./install-config.yaml** file.

2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

NOTE

If the cloud provider account that you configured on your host does not have sufficient permissions to deploy the cluster, the installation process stops, and the missing permissions are displayed.

Verification

When the cluster deployment completes successfully:

- The terminal displays directions for accessing your cluster, including a link to the web console and credentials for the **kubeadmin** user.

- Credential information also outputs to **<installation_directory>/.openshift_install.log**.

IMPORTANT

Do not delete the installation program or the files that the installation program creates. Both are required to delete the cluster.

Example output

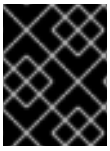
```
...
INFO Install complete!
INFO To access the cluster as the system:admin user when using 'oc', run 'export
KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
INFO Access the OpenShift web-console here: https://console-openshift-
console.apps.mycluster.example.com
INFO Login to the console with user: "kubeadmin", and password: "password"
INFO Time elapsed: 36m22s
```

IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

4.5.10. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.



IMPORTANT

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.11. Download and install the new version of **oc**.

Installing the OpenShift CLI on Linux

You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the architecture in the **Product Variant** drop-down menu.

3. Select the appropriate version in the **Version** drop-down menu.
4. Click **Download Now** next to the **OpenShift v4.11 Linux Client** entry and save the file.
5. Unpack the archive:

```
$ tar xvf <file>
```

6. Place the **oc** binary in a directory that is on your **PATH**.
   To check your **PATH**, execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.
   To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
C:\> oc <command>
```

Installing the OpenShift CLI on macOS

You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.

3. Click **Download Now** next to the **OpenShift v4.11 macOS Client** entry and save the file.

NOTE

For macOS arm64, choose the **OpenShift v4.11 macOS arm64 Client** entry.

4. Unpack and unzip the archive.

5. Move the **oc** binary to a directory on your PATH.
To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

4.5.11. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

Example output

```
system:admin
```

4.5.12. Logging in to the cluster by using the web console

The **kubeadmin** user exists by default after an OpenShift Container Platform installation. You can log in to your cluster as the **kubeadmin** user by using the OpenShift Container Platform web console.

Prerequisites

- You have access to the installation host.
- You completed a cluster installation and all cluster Operators are available.

Procedure

1. Obtain the password for the **kubeadmin** user from the **kubeadmin-password** file on the installation host:

```
$ cat <installation_directory>/auth/kubeadmin-password
```

NOTE

Alternatively, you can obtain the **kubeadmin** password from the **<installation_directory>/.openshift_install.log** log file on the installation host.

2. List the OpenShift Container Platform web console route:

```
$ oc get routes -n openshift-console | grep 'console-openshift'
```

NOTE

Alternatively, you can obtain the OpenShift Container Platform route from the **<installation_directory>/.openshift_install.log** log file on the installation host.

Example output

```
console     console-openshift-console.apps.<cluster_name>.<base_domain>          console
https   reencrypt/Redirect   None
```

3. Navigate to the route detailed in the output of the preceding command in a web browser and log in as the **kubeadmin** user.

4.5.13. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.11, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to OpenShift Cluster Manager Hybrid Cloud Console.

After you confirm that your OpenShift Cluster Manager Hybrid Cloud Console inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, use subscription watch to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

Additional resources

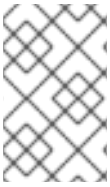
- See About remote health monitoring for more information about the Telemetry service.
- See Accessing the web console for more details about accessing and understanding the OpenShift Container Platform web console
- See Accessing the web console for more details about accessing and understanding the OpenShift Container Platform web console.

4.5.14. Next steps

- Validate an installation.
- Customize your cluster.
- If necessary, you can opt out of remote health reporting .

4.6. INSTALLING A CLUSTER ON ALIBABA CLOUD INTO AN EXISTING VPC

In OpenShift Container Platform version 4.11, you can install a cluster into an existing Alibaba Virtual Private Cloud (VPC) on Alibaba Cloud Services. The installation program provisions the required infrastructure, which can then be customized. To customize the VPC installation, modify the parameters in the 'install-config.yaml' file before you install the cluster.



NOTE

The scope of the OpenShift Container Platform installation configurations is intentionally narrow. It is designed for simplicity and ensured success. You can complete many more OpenShift Container Platform configuration tasks after an installation completes.

IMPORTANT

Alibaba Cloud on OpenShift Container Platform is a Technology Preview feature only. Technology Preview features are not supported with Red Hat production service level agreements (SLAs) and might not be functionally complete. Red Hat does not recommend using them in production. These features provide early access to upcoming product features, enabling customers to test functionality and provide feedback during the development process.

For more information about the support scope of Red Hat Technology Preview features, see Technology Preview Features Support Scope .

4.6.1. Prerequisites

- You reviewed details about the OpenShift Container Platform installation and update processes.
- You read the documentation on selecting a cluster installation method and preparing it for users.
- You registered your domain.
- If you use a firewall, you configured it to allow the sites that your cluster requires access to.

- If the cloud Resource Access Management (RAM) APIs are not accessible in your environment, or if you do not want to store an administrator-level credential secret in the **kube-system** namespace, you can manually create and maintain Resource Access Management (RAM) credentials.

4.6.2. Using a custom VPC

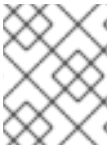
In OpenShift Container Platform 4.11, you can deploy a cluster into existing subnets in an existing Virtual Private Cloud (VPC) in the Alibaba Cloud Platform. By deploying OpenShift Container Platform into an existing Alibaba VPC, you can avoid limit constraints in new accounts and more easily adhere to your organization's operational constraints. If you cannot obtain the infrastructure creation permissions that are required to create the VPC yourself, use this installation option. You must configure networking using vSwitches.

4.6.2.1. Requirements for using your VPC

The union of the VPC CIDR block and the machine network CIDR must be non-empty. The vSwitches must be within the machine network.

The installation program does not create the following components:

- VPC
- vSwitches
- Route table
- NAT gateway



NOTE

The installation program requires that you use the cloud-provided DNS server. Using a custom DNS server is not supported and causes the installation to fail.

4.6.2.2. VPC validation

To ensure that the vSwitches you provide are suitable, the installation program confirms the following data:

- All the vSwitches that you specify must exist.
- You have provided one or more vSwitches for control plane machines and compute machines.
- The vSwitches' CIDRs belong to the machine CIDR that you specified.

4.6.2.3. Division of permissions

Some individuals can create different resources in your cloud than others. For example, you might be able to create application-specific items, like instances, buckets, and load balancers, but not networking-related components, such as VPCs or vSwitches.

4.6.2.4. Isolation between clusters

If you deploy OpenShift Container Platform into an existing network, the isolation of cluster services is reduced in the following ways:

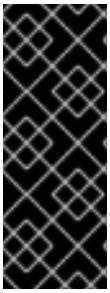
- You can install multiple OpenShift Container Platform clusters in the same VPC.
- ICMP ingress is allowed to the entire network.
- TCP 22 ingress (SSH) is allowed to the entire network.
- Control plane TCP 6443 ingress (Kubernetes API) is allowed to the entire network.
- Control plane TCP 22623 ingress (MCS) is allowed to the entire network.

4.6.3. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.11, you require access to the internet to install your cluster.

You must have internet access to:

- Access OpenShift Cluster Manager Hybrid Cloud Console to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access Quay.io to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.



IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

4.6.4. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the **~/.ssh/authorized_keys** list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The **./openshift-install gather** command also requires the SSH public key to be in place on the cluster nodes.

IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.

NOTE

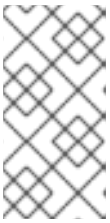
You must use a local key, not one that you configured with platform-specific approaches such as AWS key pairs.

Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N '' -f <path>/<file_name> 1
```

1 Specify the path and file name, such as ~/**.ssh/id_ed25519**, of the new SSH key. If you have an existing key pair, ensure your public key is in the your ~/**.ssh** directory.



NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS validated or Modules In Process cryptographic libraries on the **x86_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

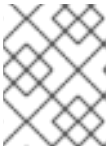
2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the ~/**.ssh/id_ed25519.pub** public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the **./openshift-install gather** command.



NOTE

On some distributions, default SSH private key identities such as ~/**.ssh/id_rsa** and ~/**.ssh/id_dsa** are managed automatically.

a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

Example output

```
Agent pid 31874
```

NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

1 Specify the path and file name for your SSH private key, such as **~/.ssh/id_ed25519**

Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

4.6.5. Obtaining the installation program

Before you install OpenShift Container Platform, download the installation file on a local computer.

Prerequisites

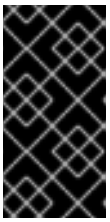
- You have a computer that runs Linux or macOS, with 500 MB of local disk space.

Procedure

1. Access the Infrastructure Provider page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program that corresponds with your host operating system and architecture, and place the file in the directory where you will store the installation configuration files.

IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.



IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation pull secret from the Red Hat OpenShift Cluster Manager . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

4.6.5.1. Creating the installation configuration file

You can customize the OpenShift Container Platform cluster you install on Alibaba Cloud.

Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.
- Obtain service principal permissions at the subscription level.

Procedure

1. Create the **install-config.yaml** file.
   a. Change to the directory that contains the installation program and run the following command:

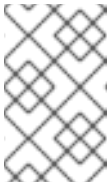
```
$ ./openshift-install create install-config --dir <installation_directory> 1
```

1 For **<installation_directory>**, specify the directory name to store the files that the installation program creates.

When specifying the directory:

- Verify that the directory has the **execute** permission. This permission is required to run Terraform binaries under the installation directory.
- Use an empty directory. Some installation assets, such as bootstrap X.509 certificates, have short expiration intervals, therefore you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

   b. At the prompts, provide the configuration details for your cloud:
      i. Optional: Select an SSH key to use to access your cluster machines.



NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

ii. Select **alibabacloud** as the platform to target.

iii. Select the region to deploy the cluster to.

iv. Select the base domain to deploy the cluster to. The base domain corresponds to the public DNS zone that you created for your cluster.

v. Provide a descriptive name for your cluster.

vi. Paste the pull secret from the Red Hat OpenShift Cluster Manager .

2. Installing the cluster into Alibaba Cloud requires that the Cloud Credential Operator (CCO) operate in manual mode. Modify the **install-config.yaml** file to set the **credentialsMode** parameter to **Manual**:

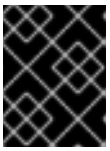
Example install-config.yaml configuration file with credentialsMode set to Manual

```
apiVersion: v1
baseDomain: cluster1.example.com
credentialsMode: Manual (1)
compute:
- architecture: amd64
  hyperthreading: Enabled
...
```

(1) Add this line to set the **credentialsMode** to **Manual**.

3. Modify the **install-config.yaml** file. You can find more information about the available parameters in the "Installation configuration parameters" section.

4. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.



IMPORTANT

The **install-config.yaml** file is consumed during the installation process. If you want to reuse the file, you must back it up now.

4.6.5.2. Installation configuration parameters

Before you deploy an OpenShift Container Platform cluster, you provide parameter values to describe your account on the cloud platform that hosts your cluster and optionally customize your cluster's platform. When you create the **install-config.yaml** installation configuration file, you provide values for the required parameters through the command line. If you customize your cluster, you can modify the **install-config.yaml** file to provide more details about the platform.

NOTE

After installation, you cannot modify these parameters in the **install-config.yaml** file.

4.6.5.2.1. Required configuration parameters

Required installation configuration parameters are described in the following table:

Table 4.15. Required parameters

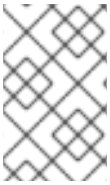
Parameter	Description	Values
apiVersion	The API version for the **install-config.yaml** content. The current version is **v1**. The installer may also support older API versions.	String
baseDomain	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the **baseDomain** and **metadata.name** parameter values that uses the **<metadata.name>.<baseDomain>** format.	A fully-qualified domain or subdomain name, such as **example.com**.
metadata	Kubernetes resource **ObjectMeta**, from which only the **name** parameter is consumed.	Object
metadata.name	The name of the cluster. DNS records for the cluster are all subdomains of **{{.metadata.name}}.{{.baseDomain}}**.	String of lowercase letters, hyphens (**-**), and periods (**.**), such as **dev**.
platform	The configuration for the specific platform upon which to perform the installation: **alibabacloud**, **aws**, **baremetal**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**. For additional information about **platform.<platform>** parameters, consult the table for your specific platform that follows.	Object

Parameter	Description	Values
pullSecret	Get a pull secret from the Red Hat OpenShift Cluster Manager to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	<pre>{ "auths":{ "cloud.openshift.com":{ "auth":"b3Blb=", "email":"you@example.com" }, "quay.io":{ "auth":"b3Blb=", "email":"you@example.com" } } }</pre>

4.6.5.2.2. Network configuration parameters

You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

Only IPv4 addresses are supported.



NOTE

Globalnet is not supported with Red Hat OpenShift Data Foundation disaster recovery solutions. For regional disaster recovery scenarios, ensure that you use a nonoverlapping range of private IP addresses for the cluster and service networks in each cluster.

Table 4.16. Network parameters

Parameter	Description	Values
networking	The configuration for the cluster network.	Object  **NOTE** You cannot modify parameters specified by the **networking** object after installation.

Parameter	Description	Values
networking.networkType	The cluster network provider Container Network Interface (CNI) cluster network provider to install.	Either **OpenShiftSDN** or **OVNKubernetes**. **OpenShiftSDN** is a CNI provider for all-Linux networks. **OVNKubernetes** is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is **OpenShiftSDN**.
networking.clusterNetwork	The IP address blocks for pods. The default value is **10.128.0.0/14** with a host prefix of **/23**. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: `networking:` `  clusterNetwork:` `  - cidr: 10.128.0.0/14` `    hostPrefix: 23`
networking.clusterNetwork.cidr	Required if you use **networking.clusterNetwork**. An IP address block. An IPv4 network.	An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between **0** and **32**.
networking.clusterNetwork.hostPrefix	The subnet prefix length to assign to each individual node. For example, if **hostPrefix** is set to **23** then each node is assigned a **/23** subnet out of the given **cidr**. A **hostPrefix** value of **23** provides 510 (2^(32 - 23) - 2) pod IP addresses.	A subnet prefix. The default value is **23**.
networking.serviceNetwork	The IP address block for services. The default value is **172.30.0.0/16**. The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.	An array with an IP address block in CIDR format. For example: `networking:` `  serviceNetwork:` `  - 172.30.0.0/16`
networking.machineNetwork	The IP address blocks for machines. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: `networking:` `  machineNetwork:` `  - cidr: 10.0.0.0/16`

Parameter	Description	Values
networking.machineNetwork.cidr	Required if you use **networking.machineNetwork**. An IP address block. The default value is **10.0.0.0/16** for all platforms other than libvirt. For libvirt, the default value is **192.168.126.0/24**.	An IP network block in CIDR notation. For example, **10.0.0.0/16**.  **NOTE** Set the **networking.machineNetwork** to match the CIDR that the preferred NIC resides in.

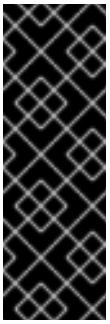
4.6.5.2.3. Optional configuration parameters

Optional installation configuration parameters are described in the following table:

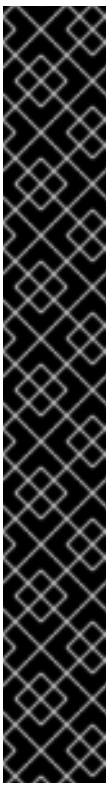
Table 4.17. Optional parameters

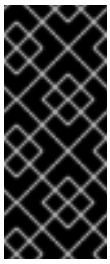
Parameter	Description	Values
additionalTrustBundle	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String
capabilities	Controls the installation of optional core cluster components. You can reduce the footprint of your OpenShift Container Platform cluster by disabling optional components.	String array
capabilities.baselineCapabilitySet	Selects an initial set of optional capabilities to enable. Valid values are **None**, **v4.11** and **vCurrent**. **v4.11** enables the **baremetal** Operator, the **marketplace** Operator, and the **openshift-samples** content. **vCurrent** installs the recommended set of capabilities for the current version of OpenShift Container Platform. The default value is **vCurrent**.	String

Parameter	Description	Values
capabilities.additionalEnabledCapabilities	Extends the set of optional capabilities beyond what you specify in **baselineCapabilitySet**. Valid values are **baremetal**, **marketplace** and **openshift-samples**. You may specify multiple capabilities in this parameter.	String array
cgroupsV2	Enables Linux control groups version 2 (cgroups v2) on specific nodes in your cluster. The OpenShift Container Platform process for enabling cgroups v2 disables all cgroup version 1 controllers and hierarchies. The OpenShift Container Platform cgroups version 2 feature is in Developer Preview and is not supported by Red Hat at this time.	**true**
compute	The configuration for the machines that comprise the compute nodes.	Array of **MachinePool** objects.
compute.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** (the default).	String
compute.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  IMPORTANT If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
compute.name	Required if you use **compute**. The name of the machine pool.	**worker**

Parameter	Description	Values
compute.platform	Required if you use **compute**. Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the **controlPlane.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
compute.replicas	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to **2**. The default value is **3**.
controlPlane	The configuration for the machines that comprise the control plane.	Array of **MachinePool** objects.
controlPlane.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** (the default).	String
controlPlane.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  IMPORTANT If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
controlPlane.name	Required if you use **controlPlane**. The name of the machine pool.	**master**

Parameter	Description	Values
controlPlane.platform	Required if you use **controlPlane**. Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the **compute.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
controlPlane.replicas	The number of control plane machines to provision.	The only supported value is **3**, which is the default value.
credentialsMode	The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported.  **NOTE** Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the *Cloud Credential Operator* entry in the *Cluster Operators reference* content.  **NOTE** If your AWS account has service control policies (SCP) enabled, you must configure the **credentialsMode** parameter to **Mint**, **Passthrough** or **Manual**.	**Mint**, **Passthrough**, **Manual** or an empty string (**""**).

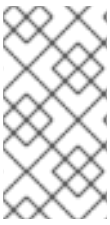
Parameter	Description	Values
fips	Enable or disable FIPS mode. The default is **false** (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.  **IMPORTANT** To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.  **NOTE** If you are using Azure File storage, you cannot enable FIPS mode.	**false** or **true**
imageContentSources	Sources and repositories for the release-image content.	Array of objects. Includes a **source** and, optionally, **mirrors**, as described in the following rows of this table.
imageContentSources.source	Required if you use **imageContentSources**. Specify the repository that users refer to, for example, in image pull specifications.	String

Parameter	Description	Values
imageContentSources.mirrors	Specify one or more repositories that may also contain the same images.	Array of strings
publish	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	**Internal** or **External**. The default value is **External**. Setting this field to **Internal** is not supported on non-cloud platforms and IBM Cloud VPC.  **IMPORTANT** If the value of the field is set to **Internal**, the cluster will become non-functional. For more information, refer to BZ#1953035.
sshKey	The SSH key to authenticate access to your cluster machines.  **NOTE** For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.	For example, **sshKey: ssh-ed25519 AAAA..**.

4.6.5.2.4. Additional Alibaba Cloud configuration parameters

Additional Alibaba Cloud configuration parameters are described in the following table. The **alibabacloud** parameters are the configuration used when installing on Alibaba Cloud. The **defaultMachinePlatform** parameters are the default configuration used when installing on Alibaba Cloud for machine pools that do not define their own platform configuration.

These parameters apply to both compute machines and control plane machines where specified.



NOTE

If defined, the parameters **compute.platform.alibabacloud** and **controlPlane.platform.alibabacloud** will overwrite **platform.alibabacloud.defaultMachinePlatform** settings for compute machines and control plane machines respectively.

Table 4.18. Optional Alibaba Cloud parameters

Parameter	Description	Values
compute.platform.alibabacloud.imageID	The imageID used to create the ECS instance. ImageID must belong to the same region as the cluster.	String.
compute.platform.alibabacloud.instanceType	InstanceType defines the ECS instance type. Example: **ecs.g6.large**	String.
compute.platform.alibabacloud.systemDiskCategory	Defines the category of the system disk. Examples: **cloud_efficiency**,**cloud_essd**	String.
compute.platform.alibabacloud.systemDisksize	Defines the size of the system disk in gibibytes (GiB).	Integer.
compute.platform.alibabacloud.zones	The list of availability zones that can be used. Examples: **cn-hangzhou-h**, **cn-hangzhou-j**	String list.
controlPlane.platform.alibabacloud.imageID	The imageID used to create the ECS instance. ImageID must belong to the same region as the cluster.	String.
controlPlane.platform.alibabacloud.instanceType	InstanceType defines the ECS instance type. Example: **ecs.g6.xlarge**	String.
controlPlane.platform.alibabacloud.systemDiskCategory	Defines the category of the system disk. Examples: **cloud_efficiency**,**cloud_essd**	String.
controlPlane.platform.alibabacloud.systemDisksize	Defines the size of the system disk in gibibytes (GiB).	Integer.
controlPlane.platform.alibabacloud.zones	The list of availability zones that can be used. Examples: **cn-hangzhou-h**, **cn-hangzhou-j**	String list.

Parameter	Description	Values
platform.alibabacloud.region	Required.The Alibaba Cloud region where the cluster will be created.	String.
platform.alibabacloud.resourceGroupID	The ID of an already existing resource group where the cluster will be installed. If empty, the installer will create a new resource group for the cluster.	String.
platform.alibabacloud.tags	Additional keys and values to apply to all Alibaba Cloud resources created for the cluster.	Object.
platform.alibabacloud.vpcID	The ID of an already existing VPC where the cluster should be installed. If empty, the installer will create a new VPC for the cluster.	String.
platform.alibabacloud.vswitchIDs	The ID list of already existing VSwitches where cluster resources will be created. The existing VSwitches can only be used when also using existing VPC. If empty, the installer will create new VSwitches for the cluster.	String list.
platform.alibabacloud.defaultMachinePlatform.imageID	For both compute machines and control plane machines, the image ID that should be used to create ECS instance. If set, the image ID should belong to the same region as the cluster.	String.
platform.alibabacloud.defaultMachinePlatform.instanceType	For both compute machines and control plane machines, the ECS instance type used to create the ECS instance. Example: **ecs.g6.xlarge**	String.

Parameter	Description	Values
platform.alibabacloud.defaultMachinePlatform.systemDiskCategory	For both compute machines and control plane machines, the category of the system disk. Examples: **cloud_efficiency**, **cloud_essd**.	String, for example "", **cloud_efficiency**, **cloud_essd**.
platform.alibabacloud.defaultMachinePlatform.systemDiskSize	For both compute machines and control plane machines, the size of the system disk in gibibytes (GiB). The minimum is **120**.	Integer.
platform.alibabacloud.defaultMachinePlatform.zones	For both compute machines and control plane machines, the list of availability zones that can be used. Examples: **cn-hangzhou-h**, **cn-hangzhou-j**	String list.
platform.alibabacloud.privateZoneID	The ID of an existing private zone into which to add DNS records for the cluster's internal API. An existing private zone can only be used when also using existing VPC. The private zone must be associated with the VPC containing the subnets. Leave the private zone unset to have the installer create the private zone on your behalf.	String.

4.6.5.3. Sample customized install-config.yaml file for Alibaba Cloud

You can customize the installation configuration file (**install-config.yaml**) to specify more details about your cluster's platform or modify the values of the required parameters.

```
apiVersion: v1
baseDomain: alicloud-dev.devcluster.openshift.com
credentialsMode: Manual
compute:
- architecture: amd64
  hyperthreading: Enabled
  name: worker
  platform: {}
  replicas: 3
controlPlane:
```

```
  architecture: amd64
  hyperthreading: Enabled
  name: master
  platform: {}
  replicas: 3
metadata:
  creationTimestamp: null
  name: test-cluster 1
 networking:
  clusterNetwork:
  - cidr: 10.128.0.0/14
    hostPrefix: 23
  machineNetwork:
  - cidr: 10.0.0.0/16
  networkType: OpenShiftSDN 2
  serviceNetwork:
  - 172.30.0.0/16
platform:
  alibabacloud:
    defaultMachinePlatform: 3
      instanceType: ecs.g6.xlarge
      systemDiskCategory: cloud_efficiency
      systemDiskSize: 200
    region: ap-southeast-1 4
    resourceGroupID: rg-acfnw6j3hyai 5
    vpcID: vpc-0xifdjerdibmaqvtjob2b
    vswitchIDs: 6
    - vsw-0xi8ycgwc8wv5rhviwdq5
    - vsw-0xiy6v3z2tedv009b4pz2
publish: External
pullSecret: '{"auths": {"cloud.openshift.com": {"auth": ... }' 7
sshKey: |
  ssh-rsa AAAA... 8
```

1 Required. The installation program prompts you for a cluster name.

2 The cluster network plugin to install. The supported values are **OVNKubernetes** and **OpenShiftSDN**. The default value is **OVNKubernetes**.

3 Optional. Specify parameters for machine pools that do not define their own platform configuration.

4 Required. The installation program prompts you for the region to deploy the cluster to.

5 Optional. Specify an existing resource group where the cluster should be installed.

7 Required. The installation program prompts you for the pull secret.

8 Optional. The installation program prompts you for the SSH key value that you use to access the machines in your cluster.

6 Optional. These are example vswitchID values.

4.6.5.4. Generating the required installation manifests

You must generate the Kubernetes manifest and Ignition config files that the cluster needs to configure the machines.

Procedure

1. Generate the manifests by running the following command from the directory that contains the installation program:

```
$ openshift-install create manifests --dir <installation_directory>
```

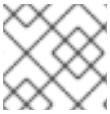
where:

<installation_directory>

Specifies the directory in which the installation program creates files.

4.6.5.5. Configuring the Cloud Credential Operator utility

To create and manage cloud credentials from outside of the cluster when the Cloud Credential Operator (CCO) is operating in manual mode, extract and prepare the CCO utility (**ccoctl**) binary.



NOTE

The **ccoctl** utility is a Linux binary that must run in a Linux environment.

Prerequisites

- You have access to an OpenShift Container Platform account with cluster administrator access.
- You have installed the OpenShift CLI (**oc**).

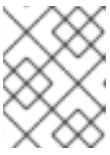
Procedure

1. Obtain the OpenShift Container Platform release image by running the following command:

```
$ RELEASE_IMAGE=$(./openshift-install version | awk '/release image/ {print $3}')
```

2. Obtain the CCO container image from the OpenShift Container Platform release image by running the following command:

```
$ CCO_IMAGE=$(oc adm release info --image-for='cloud-credential-operator'
$RELEASE_IMAGE -a ~/.pull-secret)
```



NOTE

Ensure that the architecture of the **$RELEASE_IMAGE** matches the architecture of the environment in which you will use the **ccoctl** tool.

3. Extract the **ccoctl** binary from the CCO container image within the OpenShift Container Platform release image by running the following command:

```
$ oc image extract $CCO_IMAGE --file="/usr/bin/ccoctl" -a ~/.pull-secret
```

4. Change the permissions to make **ccoctl** executable by running the following command:

```
$ chmod 775 ccoctl
```

Verification

- To verify that **ccoctl** is ready to use, display the help file by running the following command:

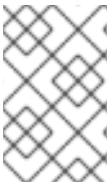
```
$ ccoctl --help
```

Output of ccoctl --help

```
OpenShift credentials provisioning tool

Usage:
  ccoctl [command]

Available Commands:
  alibabacloud Manage credentials objects for alibaba cloud
  aws          Manage credentials objects for AWS cloud
  gcp          Manage credentials objects for Google cloud
  help         Help about any command
  ibmcloud     Manage credentials objects for IBM Cloud
  nutanix      Manage credentials objects for Nutanix

Flags:
  -h, --help   help for ccoctl

Use "ccoctl [command] --help" for more information about a command.
```

4.6.5.6. Creating credentials for OpenShift Container Platform components with the ccoctl tool

You can use the OpenShift Container Platform Cloud Credential Operator (CCO) utility to automate the creation of Alibaba Cloud RAM users and policies for each in-cluster component.



NOTE

By default, **ccoctl** creates objects in the directory in which the commands are run. To create the objects in a different directory, use the **--output-dir** flag. This procedure uses **<path_to_ccoctl_output_dir>** to refer to this directory.

Prerequisites

You must have:

- Extracted and prepared the **ccoctl** binary.
- Created a RAM user with sufficient permission to create the OpenShift Container Platform cluster.
- Added the AccessKeyID (**access_key_id**) and AccessKeySecret (**access_key_secret**) of that RAM user into the **~/.alibabacloud/credentials** file on your local computer.

Procedure

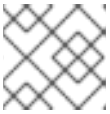
1. Set the **$RELEASE_IMAGE** variable by running the following command:

```
$ RELEASE_IMAGE=$(./openshift-install version | awk '/release image/ {print $3}')
```

2. Extract the list of **CredentialsRequest** objects from the OpenShift Container Platform release image by running the following command:

```
$ oc adm release extract \
--credentials-requests \
--cloud=alibabacloud \
--to=<path_to_directory_with_list_of_credentials_requests>/credrequests \ 1
$RELEASE_IMAGE
```

1 **credrequests** is the directory where the list of **CredentialsRequest** objects is stored. This command creates the directory if it does not exist.



NOTE

This command can take a few moments to run.

3. If your cluster uses cluster capabilities to disable one or more optional components, delete the **CredentialsRequest** custom resources for any disabled components.

Example credrequests directory contents for OpenShift Container Platform 4.12 on Alibaba Cloud

```
0000_30_machine-api-operator_00_credentials-request.yaml 1
0000_50_cluster-image-registry-operator_01-registry-credentials-request-alibaba.yaml 2
0000_50_cluster-ingress-operator_00-ingress-credentials-request.yaml 3
0000_50_cluster-storage-operator_03_credentials_request_alibaba.yaml 4
```

1 The Machine API Operator CR is required.

2 The Image Registry Operator CR is required.

3 The Ingress Operator CR is required.

4 The Storage Operator CR is an optional component and might be disabled in your cluster.

4. Use the **ccoctl** tool to process all **CredentialsRequest** objects in the **credrequests** directory:

   a. Run the following command to use the tool:

```
$ ccoctl alibabacloud create-ram-users \
--name <name> \
--region=<alibaba_region> \
--credentials-requests-dir=
<path_to_directory_with_list_of_credentials_requests>/credrequests \
--output-dir=<path_to_ccoctl_output_dir>
```

where:

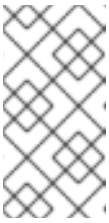
- **<name>** is the name used to tag any cloud resources that are created for tracking.
- **<alibaba_region>** is the Alibaba Cloud region in which cloud resources will be created.
- **<path_to_directory_with_list_of_credentials_requests>/credrequests** is the directory containing the files for the component **CredentialsRequest** objects.
- **<path_to_ccoctl_output_dir>** is the directory where the generated component credentials secrets will be placed.

NOTE

If your cluster uses Technology Preview features that are enabled by the **TechPreviewNoUpgrade** feature set, you must include the **--enable-tech-preview** parameter.

Example output

```
2022/02/11 16:18:26 Created RAM User: user1-alicloud-openshift-machine-api-alibabacloud-credentials
2022/02/11 16:18:27 Ready for creating new ram policy user1-alicloud-openshift-machine-api-alibabacloud-credentials-policy-policy
2022/02/11 16:18:27 RAM policy user1-alicloud-openshift-machine-api-alibabacloud-credentials-policy-policy has created
2022/02/11 16:18:28 Policy user1-alicloud-openshift-machine-api-alibabacloud-credentials-policy-policy has attached on user user1-alicloud-openshift-machine-api-alibabacloud-credentials
2022/02/11 16:18:29 Created access keys for RAM User: user1-alicloud-openshift-machine-api-alibabacloud-credentials
2022/02/11 16:18:29 Saved credentials configuration to: user1-alicloud/manifests/openshift-machine-api-alibabacloud-credentials-credentials.yaml
...
```



NOTE

A RAM user can have up to two AccessKeys at the same time. If you run **ccoctl alibabacloud create-ram-users** more than twice, the previous generated manifests secret becomes stale and you must reapply the newly generated secrets.

b. Verify that the OpenShift Container Platform secrets are created:

```
$ ls <path_to_ccoctl_output_dir>/manifests
```

Example output:

```
openshift-cluster-csi-drivers-alibaba-disk-credentials-credentials.yaml
openshift-image-registry-installer-cloud-credentials-credentials.yaml
openshift-ingress-operator-cloud-credentials-credentials.yaml
openshift-machine-api-alibabacloud-credentials-credentials.yaml
```

You can verify that the RAM users and policies are created by querying Alibaba Cloud. For more information, refer to Alibaba Cloud documentation on listing RAM users and policies.

5. Copy the generated credential files to the target manifests directory:

```
$ cp ./<path_to_ccoctl_output_dir>/manifests/*credentials.yaml
./<path_to_installation>dir>/manifests/
```

where:

<path_to_ccoctl_output_dir>
Specifies the directory created by the **ccoctl alibabacloud create-ram-users** command.

<path_to_installation_dir>
Specifies the directory in which the installation program creates files.

4.6.6. Deploying the cluster

You can install OpenShift Container Platform on a compatible cloud platform.

IMPORTANT

You can run the **create cluster** command of the installation program only once, during initial installation.

Prerequisites

- Configure an account with the cloud platform that hosts your cluster.
- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.

Procedure

- Change to the directory that contains the installation program and initialize the cluster deployment:

```
$ ./openshift-install create cluster --dir <installation_directory> \ 1
  --log-level=info 2
```

1 For **<installation_directory>**, specify the location of your customized **./install-config.yaml** file.

2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

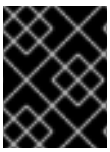
NOTE

If the cloud provider account that you configured on your host does not have sufficient permissions to deploy the cluster, the installation process stops, and the missing permissions are displayed.

Verification

When the cluster deployment completes successfully:

- The terminal displays directions for accessing your cluster, including a link to the web console and credentials for the **kubeadmin** user.
- Credential information also outputs to **<installation_directory>/.openshift_install.log**.

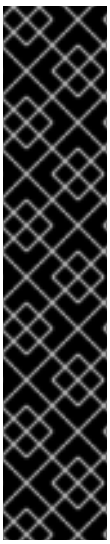


IMPORTANT

Do not delete the installation program or the files that the installation program creates. Both are required to delete the cluster.

Example output

```
...
INFO Install complete!
INFO To access the cluster as the system:admin user when using 'oc', run 'export
KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
INFO Access the OpenShift web-console here: https://console-openshift-
console.apps.mycluster.example.com
INFO Login to the console with user: "kubeadmin", and password: "password"
INFO Time elapsed: 36m22s
```

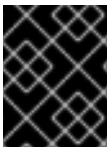


IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

4.6.7. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.



IMPORTANT

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.11. Download and install the new version of **oc**.

Installing the OpenShift CLI on Linux

You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the architecture in the **Product Variant** drop-down menu.
3. Select the appropriate version in the **Version** drop-down menu.
4. Click **Download Now** next to the **OpenShift v4.11 Linux Client** entry and save the file.
5. Unpack the archive:

```
$ tar xvf <file>
```

6. Place the **oc** binary in a directory that is on your **PATH**.
   To check your **PATH**, execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.
   To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

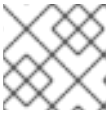
```
C:\> oc <command>
```

Installing the OpenShift CLI on macOS

You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 macOS Client** entry and save the file.



NOTE

For macOS arm64, choose the **OpenShift v4.11 macOS arm64 Client** entry.

4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your PATH.
To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

4.6.8. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

Example output

```
-
```

```
system:admin
```

4.6.9. Logging in to the cluster by using the web console

The **kubeadmin** user exists by default after an OpenShift Container Platform installation. You can log in to your cluster as the **kubeadmin** user by using the OpenShift Container Platform web console.

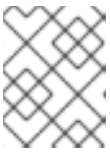
Prerequisites

- You have access to the installation host.
- You completed a cluster installation and all cluster Operators are available.

Procedure

1. Obtain the password for the **kubeadmin** user from the **kubeadmin-password** file on the installation host:

```
$ cat <installation_directory>/auth/kubeadmin-password
```



NOTE

Alternatively, you can obtain the **kubeadmin** password from the **<installation_directory>/.openshift_install.log** log file on the installation host.

2. List the OpenShift Container Platform web console route:

```
$ oc get routes -n openshift-console | grep 'console-openshift'
```

NOTE

Alternatively, you can obtain the OpenShift Container Platform route from the **<installation_directory>/.openshift_install.log** log file on the installation host.

Example output

```
console     console-openshift-console.apps.<cluster_name>.<base_domain>           console
https   reencrypt/Redirect   None
```

3. Navigate to the route detailed in the output of the preceding command in a web browser and log in as the **kubeadmin** user.

4.6.10. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.11, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to OpenShift Cluster Manager Hybrid Cloud Console.

After you confirm that your OpenShift Cluster Manager Hybrid Cloud Console inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, use

subscription watch to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

Additional resources

- See About remote health monitoring for more information about the Telemetry service.
- See Accessing the web console for more details about accessing and understanding the OpenShift Container Platform web console

4.6.11. Next steps

- Validating an installation.
- Customize your cluster.
- If necessary, you can opt out of remote health reporting .

4.7. UNINSTALLING A CLUSTER ON ALIBABA CLOUD

You can remove a cluster that you deployed to Alibaba Cloud.

4.7.1. Removing a cluster that uses installer-provisioned infrastructure

You can remove a cluster that uses installer-provisioned infrastructure from your cloud.

NOTE

After uninstallation, check your cloud provider for any resources not removed properly, especially with User Provisioned Infrastructure (UPI) clusters. There might be resources that the installer did not create or that the installer is unable to access.

Prerequisites

- You have a copy of the installation program that you used to deploy the cluster.
- You have the files that the installation program generated when you created your cluster.

Procedure

1. On the computer that you used to install the cluster, go to the directory that contains the installation program, and run the following command:

```
$ ./openshift-install destroy cluster \
--dir <installation_directory> --log-level info 1 2
```

1. For **<installation_directory>**, specify the path to the directory that you stored the installation files in.
2. To view different details, specify **warn**, **debug**, or **error** instead of **info**.

NOTE

You must specify the directory that contains the cluster definition files for your cluster. The installation program requires the **metadata.json** file in this directory to delete the cluster.

2. Optional: Delete the **<installation_directory>** directory and the OpenShift Container Platform installation program.

CHAPTER 5. INSTALLING ON AWS

5.1. PREPARING TO INSTALL ON AWS

5.1.1. Prerequisites

- You reviewed details about the OpenShift Container Platform installation and update processes.
- You read the documentation on selecting a cluster installation method and preparing it for users.

5.1.2. Requirements for installing OpenShift Container Platform on AWS

Before installing OpenShift Container Platform on Amazon Web Services (AWS), you must create an AWS account. See Configuring an AWS account for details about configuring an account, account limits, account permissions, IAM user setup, and supported AWS regions.

If the cloud identity and access management (IAM) APIs are not accessible in your environment, or if you do not want to store an administrator-level credential secret in the **kube-system** namespace, see Manually creating IAM for AWS for other options, including configuring the Cloud Credential Operator (CCO) to use the Amazon Web Services Security Token Service (AWS STS).

5.1.3. Choosing a method to install OpenShift Container Platform on AWS

You can install OpenShift Container Platform on installer-provisioned or user-provisioned infrastructure. The default installation type uses installer-provisioned infrastructure, where the installation program provisions the underlying infrastructure for the cluster. You can also install OpenShift Container Platform on infrastructure that you provision. If you do not use infrastructure that the installation program provisions, you must manage and maintain the cluster resources yourself.

See Installation process for more information about installer-provisioned and user-provisioned installation processes.

5.1.3.1. Installing a cluster on installer-provisioned infrastructure

You can install a cluster on AWS infrastructure that is provisioned by the OpenShift Container Platform installation program, by using one of the following methods:

- **Installing a cluster quickly on AWS**: You can install OpenShift Container Platform on AWS infrastructure that is provisioned by the OpenShift Container Platform installation program. You can install a cluster quickly by using the default configuration options.
- **Installing a customized cluster on AWS**: You can install a customized cluster on AWS infrastructure that the installation program provisions. The installation program allows for some customization to be applied at the installation stage. Many other customization options are available post-installation.
- **Installing a cluster on AWS with network customizations**: You can customize your OpenShift Container Platform network configuration during installation, so that your cluster can coexist with your existing IP address allocations and adhere to your network requirements.
- **Installing a cluster on AWS in a restricted network**: You can install OpenShift Container Platform on AWS on installer-provisioned infrastructure by using an internal mirror of the

installation release content. You can use this method to install a cluster that does not require an active internet connection to obtain the software components.

- **Installing a cluster on an existing Virtual Private Cloud**: You can install OpenShift Container Platform on an existing AWS Virtual Private Cloud (VPC). You can use this installation method if you have constraints set by the guidelines of your company, such as limits when creating new accounts or infrastructure.

- **Installing a private cluster on an existing VPC**: You can install a private cluster on an existing AWS VPC. You can use this method to deploy OpenShift Container Platform on an internal network that is not visible to the internet.

- **Installing a cluster on AWS into a government or secret region**: OpenShift Container Platform can be deployed into AWS regions that are specifically designed for US government agencies at the federal, state, and local level, as well as contractors, educational institutions, and other US customers that must run sensitive workloads in the cloud.

5.1.3.2. Installing a cluster on user-provisioned infrastructure

You can install a cluster on AWS infrastructure that you provision, by using one of the following methods:

- **Installing a cluster on AWS infrastructure that you provide**: You can install OpenShift Container Platform on AWS infrastructure that you provide. You can use the provided CloudFormation templates to create stacks of AWS resources that represent each of the components required for an OpenShift Container Platform installation.

- **Installing a cluster on AWS in a restricted network with user-provisioned infrastructure**: You can install OpenShift Container Platform on AWS infrastructure that you provide by using an internal mirror of the installation release content. You can use this method to install a cluster that does not require an active internet connection to obtain the software components. You can also use this installation method to ensure that your clusters only use container images that satisfy your organizational controls on external content. While you can install OpenShift Container Platform by using the mirrored content, your cluster still requires internet access to use the AWS APIs.

5.1.4. Next steps

- Configuring an AWS account

5.2. CONFIGURING AN AWS ACCOUNT

Before you can install OpenShift Container Platform, you must configure an Amazon Web Services (AWS) account.

5.2.1. Configuring Route 53

To install OpenShift Container Platform, the Amazon Web Services (AWS) account you use must have a dedicated public hosted zone in your Route 53 service. This zone must be authoritative for the domain. The Route 53 service provides cluster DNS resolution and name lookup for external connections to the cluster.

Procedure

1. Identify your domain, or subdomain, and registrar. You can transfer an existing domain and registrar or obtain a new one through AWS or another source.

NOTE

If you purchase a new domain through AWS, it takes time for the relevant DNS changes to propagate. For more information about purchasing domains through AWS, see Registering Domain Names Using Amazon Route 53 in the AWS documentation.

2. If you are using an existing domain and registrar, migrate its DNS to AWS. See Making Amazon Route 53 the DNS Service for an Existing Domain in the AWS documentation.

3. Create a public hosted zone for your domain or subdomain. See Creating a Public Hosted Zone in the AWS documentation.
   Use an appropriate root domain, such as **openshiftcorp.com**, or subdomain, such as **clusters.openshiftcorp.com**.

4. Extract the new authoritative name servers from the hosted zone records. See Getting the Name Servers for a Public Hosted Zone in the AWS documentation.

5. Update the registrar records for the AWS Route 53 name servers that your domain uses. For example, if you registered your domain to a Route 53 service in a different accounts, see the following topic in the AWS documentation: Adding or Changing Name Servers or Glue Records.

6. If you are using a subdomain, add its delegation records to the parent domain. This gives Amazon Route 53 responsibility for the subdomain. Follow the delegation procedure outlined by the DNS provider of the parent domain. See Creating a subdomain that uses Amazon Route 53 as the DNS service without migrating the parent domain in the AWS documentation for an example high level procedure.

5.2.1.1. Ingress Operator endpoint configuration for AWS Route 53

If you install in either Amazon Web Services (AWS) GovCloud (US) US-West or US-East region, the Ingress Operator uses **us-gov-west-1** region for Route53 and tagging API clients.

The Ingress Operator uses **https://tagging.us-gov-west-1.amazonaws.com** as the tagging API endpoint if a tagging custom endpoint is configured that includes the string 'us-gov-east-1'.

For more information on AWS GovCloud (US) endpoints, see the Service Endpoints in the AWS documentation about GovCloud (US).

IMPORTANT

Private, disconnected installations are not supported for AWS GovCloud when you install in the **us-gov-east-1** region.

Example Route 53 configuration

```
platform:
  aws:
    region: us-gov-west-1
    serviceEndpoints:
    - name: ec2
      url: https://ec2.us-gov-west-1.amazonaws.com
    - name: elasticloadbalancing
      url: https://elasticloadbalancing.us-gov-west-1.amazonaws.com
    - name: route53
```

```
    url: https://route53.us-gov.amazonaws.com 1
  - name: tagging
    url: https://tagging.us-gov-west-1.amazonaws.com 2
```

1 Route 53 defaults to **https://route53.us-gov.amazonaws.com** for both AWS GovCloud (US) regions.

2 Only the US-West region has endpoints for tagging. Omit this parameter if your cluster is in another region.

5.2.2. AWS account limits

The OpenShift Container Platform cluster uses a number of Amazon Web Services (AWS) components, and the default Service Limits affect your ability to install OpenShift Container Platform clusters. If you use certain cluster configurations, deploy your cluster in certain AWS regions, or run multiple clusters from your account, you might need to request additional resources for your AWS account.

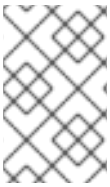
The following table summarizes the AWS components whose limits can impact your ability to install and run OpenShift Container Platform clusters.

Component	Number of clusters available by default	Default AWS limit	Description
Instance Limits	Varies	Varies	By default, each cluster creates the following instances: • One bootstrap machine, which is removed after installation • Three control plane nodes • Three worker nodes These instance type counts are within a new account's default limit. To deploy more worker nodes, enable autoscaling, deploy large workloads, or use a different instance type, review your account limits to ensure that your cluster can deploy the machines that you need. In most regions, the worker machines use an **m6i.large** instance and the bootstrap and control plane machines use **m6i.xlarge** instances. In some regions, including all regions that do not support these instance types, **m5.large** and **m5.xlarge** instances are used instead.

Component	Number of clusters available by default	Default AWS limit	Description
Elastic IPs (EIPs)	0 to 1	5 EIPs per account	To provision the cluster in a highly available configuration, the installation program creates a public and private subnet for each availability zone within a region. Each private subnet requires aNAT Gateway, and each NAT gateway requires a separate elastic IP. Review the AWS region map to determine how many availability zones are in each region. To take advantage of the default high availability, install the cluster in a region with at least three availability zones. To install a cluster in a region with more than five availability zones, you must increase the EIP limit.  **IMPORTANT** To use the **us-east-1** region, you must increase the EIP limit for your account.
Virtual Private Clouds (VPCs)	5	5 VPCs per region	Each cluster creates its own VPC.
Elastic Load Balancing (ELB/NLB)	3	20 per region	By default, each cluster creates internal and external network load balancers for the master API server and a single Classic Load Balancer for the router. Deploying more Kubernetes **Service** objects with type **LoadBalancer** will create additional load balancers.
NAT Gateways	5	5 per availability zone	The cluster deploys one NAT gateway in each availability zone.
Elastic Network Interfaces (ENIs)	At least 12	350 per region	The default installation creates 21 ENIs and an ENI for each availability zone in your region. For example, the **us-east-1** region contains six availability zones, so a cluster that is deployed in that zone uses 27 ENIs. Review the AWS region map to determine how many availability zones are in each region. Additional ENIs are created for additional machines and ELB load balancers that are created by cluster usage and deployed workloads.

Component	Number of clusters available by default	Default AWS limit	Description
VPC Gateway	20	20 per account	Each cluster creates a single VPC Gateway for S3 access.
S3 buckets	99	100 buckets per account	Because the installation process creates a temporary bucket and the registry component in each cluster creates a bucket, you can create only 99 OpenShift Container Platform clusters per AWS account.
Security Groups	250	2,500 per account	Each cluster creates 10 distinct security groups.

5.2.3. Required AWS permissions for the IAM user



NOTE

Your IAM user must have the permission **tag:GetResources** in the region **us-east-1** to delete the base cluster resources. As part of the AWS API requirement, the OpenShift Container Platform installation program performs various actions in this region.

When you attach the **AdministratorAccess** policy to the IAM user that you create in Amazon Web Services (AWS), you grant that user all of the required permissions. To deploy all components of an OpenShift Container Platform cluster, the IAM user requires the following permissions:

Example 5.1. Required EC2 permissions for installation

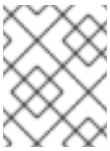
- **ec2:AuthorizeSecurityGroupEgress**
- **ec2:AuthorizeSecurityGroupIngress**
- **ec2:CopyImage**
- **ec2:CreateNetworkInterface**
- **ec2:AttachNetworkInterface**
- **ec2:CreateSecurityGroup**
- **ec2:CreateTags**
- **ec2:CreateVolume**
- **ec2:DeleteSecurityGroup**
- **ec2:DeleteSnapshot**
- **ec2:DeleteTags**

- **ec2:DeregisterImage**
- **ec2:DescribeAccountAttributes**
- **ec2:DescribeAddresses**
- **ec2:DescribeAvailabilityZones**
- **ec2:DescribeDhcpOptions**
- **ec2:DescribeImages**
- **ec2:DescribeInstanceAttribute**
- **ec2:DescribeInstanceCreditSpecifications**
- **ec2:DescribeInstances**
- **ec2:DescribeInstanceTypes**
- **ec2:DescribeInternetGateways**
- **ec2:DescribeKeyPairs**
- **ec2:DescribeNatGateways**
- **ec2:DescribeNetworkAcls**
- **ec2:DescribeNetworkInterfaces**
- **ec2:DescribePrefixLists**
- **ec2:DescribeRegions**
- **ec2:DescribeRouteTables**
- **ec2:DescribeSecurityGroups**
- **ec2:DescribeSubnets**
- **ec2:DescribeTags**
- **ec2:DescribeVolumes**
- **ec2:DescribeVpcAttribute**
- **ec2:DescribeVpcClassicLink**
- **ec2:DescribeVpcClassicLinkDnsSupport**
- **ec2:DescribeVpcEndpoints**
- **ec2:DescribeVpcs**
- **ec2:GetEbsDefaultKmsKeyId**
- **ec2:ModifyInstanceAttribute**

- **ec2:ModifyNetworkInterfaceAttribute**
- **ec2:RevokeSecurityGroupEgress**
- **ec2:RevokeSecurityGroupIngress**
- **ec2:RunInstances**
- **ec2:TerminateInstances**

Example 5.2. Required permissions for creating network resources during installation

- **ec2:AllocateAddress**
- **ec2:AssociateAddress**
- **ec2:AssociateDhcpOptions**
- **ec2:AssociateRouteTable**
- **ec2:AttachInternetGateway**
- **ec2:CreateDhcpOptions**
- **ec2:CreateInternetGateway**
- **ec2:CreateNatGateway**
- **ec2:CreateRoute**
- **ec2:CreateRouteTable**
- **ec2:CreateSubnet**
- **ec2:CreateVpc**
- **ec2:CreateVpcEndpoint**
- **ec2:ModifySubnetAttribute**
- **ec2:ModifyVpcAttribute**



NOTE

If you use an existing VPC, your account does not require these permissions for creating network resources.

Example 5.3. Required Elastic Load Balancing permissions (ELB) for installation

- **elasticloadbalancing:AddTags**
- **elasticloadbalancing:ApplySecurityGroupsToLoadBalancer**
- **elasticloadbalancing:AttachLoadBalancerToSubnets**

- **elasticloadbalancing:ConfigureHealthCheck**
- **elasticloadbalancing:CreateLoadBalancer**
- **elasticloadbalancing:CreateLoadBalancerListeners**
- **elasticloadbalancing:DeleteLoadBalancer**
- **elasticloadbalancing:DeregisterInstancesFromLoadBalancer**
- **elasticloadbalancing:DescribeInstanceHealth**
- **elasticloadbalancing:DescribeLoadBalancerAttributes**
- **elasticloadbalancing:DescribeLoadBalancers**
- **elasticloadbalancing:DescribeTags**
- **elasticloadbalancing:ModifyLoadBalancerAttributes**
- **elasticloadbalancing:RegisterInstancesWithLoadBalancer**
- **elasticloadbalancing:SetLoadBalancerPoliciesOfListener**

Example 5.4. Required Elastic Load Balancing permissions (ELBv2) for installation

- **elasticloadbalancing:AddTags**
- **elasticloadbalancing:CreateListener**
- **elasticloadbalancing:CreateLoadBalancer**
- **elasticloadbalancing:CreateTargetGroup**
- **elasticloadbalancing:DeleteLoadBalancer**
- **elasticloadbalancing:DeregisterTargets**
- **elasticloadbalancing:DescribeListeners**
- **elasticloadbalancing:DescribeLoadBalancerAttributes**
- **elasticloadbalancing:DescribeLoadBalancers**
- **elasticloadbalancing:DescribeTargetGroupAttributes**
- **elasticloadbalancing:DescribeTargetHealth**
- **elasticloadbalancing:ModifyLoadBalancerAttributes**
- **elasticloadbalancing:ModifyTargetGroup**
- **elasticloadbalancing:ModifyTargetGroupAttributes**
- **elasticloadbalancing:RegisterTargets**

Example 5.5. Required IAM permissions for installation

- **iam:AddRoleToInstanceProfile**
- **iam:CreateInstanceProfile**
- **iam:CreateRole**
- **iam:DeleteInstanceProfile**
- **iam:DeleteRole**
- **iam:DeleteRolePolicy**
- **iam:GetInstanceProfile**
- **iam:GetRole**
- **iam:GetRolePolicy**
- **iam:GetUser**
- **iam:ListInstanceProfilesForRole**
- **iam:ListRoles**
- **iam:ListUsers**
- **iam:PassRole**
- **iam:PutRolePolicy**
- **iam:RemoveRoleFromInstanceProfile**
- **iam:SimulatePrincipalPolicy**
- **iam:TagRole**

NOTE

If you have not created an elastic load balancer (ELB) in your AWS account, the IAM user also requires the **iam:CreateServiceLinkedRole** permission.

Example 5.6. Required Route 53 permissions for installation

- **route53:ChangeResourceRecordSets**
- **route53:ChangeTagsForResource**
- **route53:CreateHostedZone**
- **route53:DeleteHostedZone**
- **route53:GetChange**

- **route53:GetHostedZone**
- **route53:ListHostedZones**
- **route53:ListHostedZonesByName**
- **route53:ListResourceRecordSets**
- **route53:ListTagsForResource**
- **route53:UpdateHostedZoneComment**

Example 5.7. Required S3 permissions for installation

- **s3:CreateBucket**
- **s3:DeleteBucket**
- **s3:GetAccelerateConfiguration**
- **s3:GetBucketAcl**
- **s3:GetBucketCors**
- **s3:GetBucketLocation**
- **s3:GetBucketLogging**
- **s3:GetBucketPolicy**
- **s3:GetBucketObjectLockConfiguration**
- **s3:GetBucketReplication**
- **s3:GetBucketRequestPayment**
- **s3:GetBucketTagging**
- **s3:GetBucketVersioning**
- **s3:GetBucketWebsite**
- **s3:GetEncryptionConfiguration**
- **s3:GetLifecycleConfiguration**
- **s3:GetReplicationConfiguration**
- **s3:ListBucket**
- **s3:PutBucketAcl**
- **s3:PutBucketTagging**
- **s3:PutEncryptionConfiguration**

Example 5.8. S3 permissions that cluster Operators require

- **s3:DeleteObject**
- **s3:GetObject**
- **s3:GetObjectAcl**
- **s3:GetObjectTagging**
- **s3:GetObjectVersion**
- **s3:PutObject**
- **s3:PutObjectAcl**
- **s3:PutObjectTagging**

Example 5.9. Required permissions to delete base cluster resources

- **autoscaling:DescribeAutoScalingGroups**
- **ec2:DeletePlacementGroup**
- **ec2:DeleteNetworkInterface**
- **ec2:DeleteVolume**
- **elasticloadbalancing:DeleteTargetGroup**
- **elasticloadbalancing:DescribeTargetGroups**
- **iam:DeleteAccessKey**
- **iam:DeleteUser**
- **iam:ListAttachedRolePolicies**
- **iam:ListInstanceProfiles**
- **iam:ListRolePolicies**
- **iam:ListUserPolicies**
- **s3:DeleteObject**
- **s3:ListBucketVersions**
- **tag:GetResources**

Example 5.10. Required permissions to delete network resources

- **ec2:DeleteDhcpOptions**
- **ec2:DeleteInternetGateway**

- **ec2:DeleteNatGateway**
- **ec2:DeleteRoute**
- **ec2:DeleteRouteTable**
- **ec2:DeleteSubnet**
- **ec2:DeleteVpc**
- **ec2:DeleteVpcEndpoints**
- **ec2:DetachInternetGateway**
- **ec2:DisassociateRouteTable**
- **ec2:ReleaseAddress**
- **ec2:ReplaceRouteTableAssociation**

NOTE

If you use an existing VPC, your account does not require these permissions to delete network resources. Instead, your account only requires the **tag:UntagResources** permission to delete network resources.

Example 5.11. Required permissions to delete a cluster with shared instance roles

- **iam:UntagRole**

Example 5.12. Additional IAM and S3 permissions that are required to create manifests

- **iam:DeleteAccessKey**
- **iam:DeleteUser**
- **iam:DeleteUserPolicy**
- **iam:GetUserPolicy**
- **iam:ListAccessKeys**
- **iam:PutUserPolicy**
- **iam:TagUser**
- **s3:PutBucketPublicAccessBlock**
- **s3:GetBucketPublicAccessBlock**
- **s3:PutLifecycleConfiguration**
- **s3:HeadBucket**

- **s3:ListBucketMultipartUploads**
- **s3:AbortMultipartUpload**

NOTE

If you are managing your cloud provider credentials with mint mode, the IAM user also requires the **iam:CreateAccessKey** and **iam:CreateUser** permissions.

Example 5.13. Optional permissions for instance and quota checks for installation

- **ec2:DescribeInstanceTypeOfferings**
- **servicequotas:ListAWSDefaultServiceQuotas**

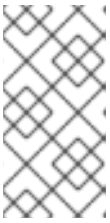
5.2.4. Creating an IAM user

Each Amazon Web Services (AWS) account contains a root user account that is based on the email address you used to create the account. This is a highly-privileged account, and it is recommended to use it for only initial account and billing configuration, creating an initial set of users, and securing the account.

Before you install OpenShift Container Platform, create a secondary IAM administrative user. As you complete the Creating an IAM User in Your AWS Account procedure in the AWS documentation, set the following options:

Procedure

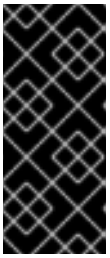
1. Specify the IAM user name and select **Programmatic access**.
2. Attach the **AdministratorAccess** policy to ensure that the account has sufficient permission to create the cluster. This policy provides the cluster with the ability to grant credentials to each OpenShift Container Platform component. The cluster grants the components only the credentials that they require.



NOTE

While it is possible to create a policy that grants the all of the required AWS permissions and attach it to the user, this is not the preferred option. The cluster will not have the ability to grant additional credentials to individual components, so the same credentials are used by all components.

3. Optional: Add metadata to the user by attaching tags.
4. Confirm that the user name that you specified is granted the **AdministratorAccess** policy.
5. Record the access key ID and secret access key values. You must use these values when you configure your local machine to run the installation program.



IMPORTANT

You cannot use a temporary session token that you generated while using a multi-factor authentication device to authenticate to AWS when you deploy a cluster. The cluster continues to use your current AWS credentials to create AWS resources for the entire life of the cluster, so you must use key-based, long-lived credentials.

Additional resources

- See Manually creating IAM for AWS for steps to set the Cloud Credential Operator (CCO) to manual mode prior to installation. Use this mode in environments where the cloud identity and access management (IAM) APIs are not reachable, or if you prefer not to store an administrator-level credential secret in the cluster **kube-system** project.

5.2.5. IAM Policies and AWS authentication

By default, the installation program creates instance profiles for the bootstrap, control plane, and compute instances with the necessary permissions for the cluster to operate.

However, you can create your own IAM roles and specify them as part of the installation process. You might need to specify your own roles to deploy the cluster or to manage the cluster after installation. For example:

- Your organization's security policies require that you use a more restrictive set of permissions to install the cluster.
- After the installation, the cluster is configured with an Operator that requires access to additional services.

If you choose to specify your own IAM roles, you can take the following steps:

- Begin with the default policies and adapt as required. For more information, see "Default permissions for IAM instance profiles".
- Use the AWS Identity and Access Management Access Analyzer (IAM Access Analyzer) to create a policy template that is based on the cluster's activity. For more information see, "Using AWS IAM Analyzer to create policy templates".

5.2.5.1. Default permissions for IAM instance profiles

By default, the installation program creates IAM instance profiles for the bootstrap, control plane and worker instances with the necessary permissions for the cluster to operate.

The following lists specify the default permissions for control plane and compute machines:

Example 5.14. Default IAM role permissions for control plane instance profiles

- **ec2:AttachVolume**
- **ec2:AuthorizeSecurityGroupIngress**
- **ec2:CreateSecurityGroup**
- **ec2:CreateTags**

- **ec2:CreateVolume**
- **ec2:DeleteSecurityGroup**
- **ec2:DeleteVolume**
- **ec2:Describe***
- **ec2:DetachVolume**
- **ec2:ModifyInstanceAttribute**
- **ec2:ModifyVolume**
- **ec2:RevokeSecurityGroupIngress**
- **elasticloadbalancing:AddTags**
- **elasticloadbalancing:AttachLoadBalancerToSubnets**
- **elasticloadbalancing:ApplySecurityGroupsToLoadBalancer**
- **elasticloadbalancing:CreateListener**
- **elasticloadbalancing:CreateLoadBalancer**
- **elasticloadbalancing:CreateLoadBalancerPolicy**
- **elasticloadbalancing:CreateLoadBalancerListeners**
- **elasticloadbalancing:CreateTargetGroup**
- **elasticloadbalancing:ConfigureHealthCheck**
- **elasticloadbalancing:DeleteListener**
- **elasticloadbalancing:DeleteLoadBalancer**
- **elasticloadbalancing:DeleteLoadBalancerListeners**
- **elasticloadbalancing:DeleteTargetGroup**
- **elasticloadbalancing:DeregisterInstancesFromLoadBalancer**
- **elasticloadbalancing:DeregisterTargets**
- **elasticloadbalancing:Describe***
- **elasticloadbalancing:DetachLoadBalancerFromSubnets**
- **elasticloadbalancing:ModifyListener**
- **elasticloadbalancing:ModifyLoadBalancerAttributes**
- **elasticloadbalancing:ModifyTargetGroup**
- **elasticloadbalancing:ModifyTargetGroupAttributes**

- **elasticloadbalancing:RegisterInstancesWithLoadBalancer**
- **elasticloadbalancing:RegisterTargets**
- **elasticloadbalancing:SetLoadBalancerPoliciesForBackendServer**
- **elasticloadbalancing:SetLoadBalancerPoliciesOfListener**
- **kms:DescribeKey**

Example 5.15. Default IAM role permissions for compute instance profiles

- **ec2:DescribeInstances**
- **ec2:DescribeRegions**

5.2.5.2. Specifying an existing IAM role

Instead of allowing the installation program to create IAM instance profiles with the default permissions, you can use the **install-config.yaml** file to specify an existing IAM role for control plane and compute instances.

Prerequisites

- You have an existing **install-config.yaml** file.

Procedure

1. Update **compute.platform.aws.iamRole** with an existing role for the control plane machines.

   Sample install-config.yaml file with an IAM role for compute instances

   ```
   compute:
   - hyperthreading: Enabled
     name: worker
     platform:
       aws:
         iamRole: ExampleRole
   ```

2. Update **controlPlane.platform.aws.iamRole** with an existing role for the compute machines.

   Sample install-config.yaml file with an IAM role for control plane instances

   ```
   controlPlane:
     hyperthreading: Enabled
     name: master
     platform:
       aws:
         iamRole: ExampleRole
   ```

3. Save the file and reference it when installing the OpenShift Container Platform cluster.

Additional resources

- See Deploying the cluster.

5.2.5.3. Using AWS IAM Analyzer to create policy templates

The minimal set of permissions that the control plane and compute instance profiles require depends on how the cluster is configured for its daily operation.

One way to determine which permissions the cluster instances require is to use the AWS Identity and Access Management Access Analyzer (IAM Access Analyzer) to create a policy template:

- A policy template contains the permissions the cluster has used over a specified period of time.
- You can then use the template to create policies with fine-grained permissions.

Procedure

The overall process could be:

1. Ensure that CloudTrail is enabled. CloudTrail records all of the actions and events in your AWS account, including the API calls that are required to create a policy template. For more information, see the AWS documentation for working with CloudTrail.
2. Create an instance profile for control plane instances and an instance profile for compute instances. Be sure to assign each role a permissive policy, such as PowerUserAccess. For more information, see the AWS documentation for creating instance profile roles.
3. Install the cluster in a development environment and configure it as required. Be sure to deploy all of applications the cluster will host in a production environment.
4. Test the cluster thoroughly. Testing the cluster ensures that all of the required API calls are logged.
5. Use the IAM Access Analyzer to create a policy template for each instance profile. For more information, see the AWS documentation for generating policies based on the CloudTrail logs .
6. Create and add a fine-grained policy to each instance profile.
7. Remove the permissive policy from each instance profile.
8. Deploy a production cluster using the existing instance profiles with the new policies.

NOTE

You can add IAM Conditions to your policy to make it more restrictive and compliant with your organization security requirements.

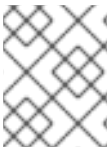
5.2.6. Supported AWS Marketplace regions

Installing an OpenShift Container Platform cluster using an AWS Marketplace image is available to customers who purchase the offer in North America.

While the offer must be purchased in North America, you can deploy the cluster to any of the following supported paritions:

- Public

- GovCloud

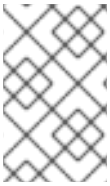


NOTE

Deploying a OpenShift Container Platform cluster using an AWS Marketplace image is not supported for the AWS secret regions or China regions.

5.2.7. Supported AWS regions

You can deploy an OpenShift Container Platform cluster to the following regions.



NOTE

Your IAM user must have the permission **tag:GetResources** in the region **us-east-1** to delete the base cluster resources. As part of the AWS API requirement, the OpenShift Container Platform installation program performs various actions in this region.

5.2.7.1. AWS public regions

The following AWS public regions are supported:

- **af-south-1** (Cape Town)
- **ap-east-1** (Hong Kong)
- **ap-northeast-1** (Tokyo)
- **ap-northeast-2** (Seoul)
- **ap-northeast-3** (Osaka)
- **ap-south-1** (Mumbai)
- **ap-south-2** (Hyderabad)
- **ap-southeast-1** (Singapore)
- **ap-southeast-2** (Sydney)
- **ap-southeast-3** (Jakarta)
- **ap-southeast-4** (Melbourne)
- **ca-central-1** (Central)
- **eu-central-1** (Frankfurt)
- **eu-central-2** (Zurich)
- **eu-north-1** (Stockholm)
- **eu-south-1** (Milan)
- **eu-south-2** (Spain)
- **eu-west-1** (Ireland)

- **eu-west-2** (London)
- **eu-west-3** (Paris)
- **me-central-1** (UAE)
- **me-south-1** (Bahrain)
- **sa-east-1** (São Paulo)
- **us-east-1** (N. Virginia)
- **us-east-2** (Ohio)
- **us-west-1** (N. California)
- **us-west-2** (Oregon)

5.2.7.2. AWS GovCloud regions

The following AWS GovCloud regions are supported:

- **us-gov-west-1**
- **us-gov-east-1**

5.2.7.3. AWS SC2S and C2S secret regions

The following AWS secret regions are supported:

- **us-isob-east-1** Secret Commercial Cloud Services (SC2S)
- **us-iso-east-1** Commercial Cloud Services (C2S)

5.2.7.4. AWS China regions

The following AWS China regions are supported:

- **cn-north-1** (Beijing)
- **cn-northwest-1** (Ningxia)

5.2.8. Next steps

- Install an OpenShift Container Platform cluster:
  - Quickly install a cluster with default options on installer-provisioned infrastructure
  - Install a cluster with cloud customizations on installer-provisioned infrastructure
  - Install a cluster with network customizations on installer-provisioned infrastructure
  - Installing a cluster on user-provisioned infrastructure in AWS by using CloudFormation templates

5.3. MANUALLY CREATING IAM FOR AWS

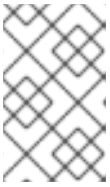
In environments where the cloud identity and access management (IAM) APIs are not reachable, or the administrator prefers not to store an administrator-level credential secret in the cluster **kube-system** namespace, you can put the Cloud Credential Operator (CCO) into manual mode before you install the cluster.

5.3.1. Alternatives to storing administrator-level secrets in the kube-system project

The Cloud Credential Operator (CCO) manages cloud provider credentials as Kubernetes custom resource definitions (CRDs). You can configure the CCO to suit the security requirements of your organization by setting different values for the **credentialsMode** parameter in the **install-config.yaml** file.

If you prefer not to store an administrator-level credential secret in the cluster **kube-system** project, you can choose one of the following options when installing OpenShift Container Platform:

- **Use the Amazon Web Services Security Token Service**
  You can use the CCO utility (**ccoctl**) to configure the cluster to use the Amazon Web Services Security Token Service (AWS STS). When the CCO utility is used to configure the cluster for STS, it assigns IAM roles that provide short-term, limited-privilege security credentials to components.

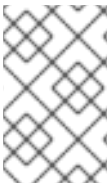


NOTE

This credentials strategy is supported for only new OpenShift Container Platform clusters and must be configured during installation. You cannot reconfigure an existing cluster that uses a different credentials strategy to use this feature.

- **Manage cloud credentials manually**.
  You can set the **credentialsMode** parameter for the CCO to **Manual** to manage cloud credentials manually. Using manual mode allows each cluster component to have only the permissions it requires, without storing an administrator-level credential in the cluster. You can also use this mode if your environment does not have connectivity to the cloud provider public IAM endpoint. However, you must manually reconcile permissions with new release images for every upgrade. You must also manually supply credentials for every component that requests them.

- **Remove the administrator-level credential secret after installing OpenShift Container Platform with mint mode**:
  If you are using the CCO with the **credentialsMode** parameter set to **Mint**, you can remove or rotate the administrator-level credential after installing OpenShift Container Platform. Mint mode is the default configuration for the CCO. This option requires the presence of the administrator-level credential during an installation. The administrator-level credential is used during the installation to mint other credentials with some permissions granted. The original credential secret is not stored in the cluster permanently.



NOTE

Prior to a non z-stream upgrade, you must reinstate the credential secret with the administrator-level credential. If the credential is not present, the upgrade might be blocked.

Additional resources

- To learn how to use the CCO utility (**ccoctl**) to configure the CCO to use the AWS STS, see Using manual mode with STS.
- To learn how to rotate or remove the administrator-level credential secret after installing OpenShift Container Platform, see Rotating or removing cloud provider credentials.
- For a detailed description of all available CCO credential modes and their supported platforms, see About the Cloud Credential Operator.

5.3.2. Manually create IAM

The Cloud Credential Operator (CCO) can be put into manual mode prior to installation in environments where the cloud identity and access management (IAM) APIs are not reachable, or the administrator prefers not to store an administrator-level credential secret in the cluster **kube-system** namespace.

Procedure

1. Change to the directory that contains the installation program and create the **install-config.yaml** file by running the following command:

   ```
   $ openshift-install create install-config --dir <installation_directory>
   ```

   where **<installation_directory>** is the directory in which the installation program creates files.

2. Edit the **install-config.yaml** configuration file so that it contains the **credentialsMode** parameter set to **Manual**.

   Example install-config.yaml configuration file

   ```
   apiVersion: v1
   baseDomain: cluster1.example.com
   credentialsMode: Manual (1)
   compute:
   - architecture: amd64
     hyperthreading: Enabled
   ...
   ```

   (1) This line is added to set the **credentialsMode** parameter to **Manual**.

3. Generate the manifests by running the following command from the directory that contains the installation program:

   ```
   $ openshift-install create manifests --dir <installation_directory>
   ```

   where **<installation_directory>** is the directory in which the installation program creates files.

4. From the directory that contains the installation program, obtain details of the OpenShift Container Platform release image that your **openshift-install** binary is built to use by running the following command:

   ```
   $ openshift-install version
   ```

Example output

```
release image quay.io/openshift-release-dev/ocp-release:4.y.z-x86_64
```

5. Locate all **CredentialsRequest** objects in this release image that target the cloud you are deploying on by running the following command:

```
$ oc adm release extract quay.io/openshift-release-dev/ocp-release:4.y.z-x86_64 \
  --credentials-requests \
  --cloud=aws
```

This command creates a YAML file for each **CredentialsRequest** object.

Sample CredentialsRequest object

```
apiVersion: cloudcredential.openshift.io/v1
kind: CredentialsRequest
metadata:
  name: <component-credentials-request>
  namespace: openshift-cloud-credential-operator
  ...
spec:
  providerSpec:
    apiVersion: cloudcredential.openshift.io/v1
    kind: AWSProviderSpec
    statementEntries:
    - effect: Allow
      action:
      - iam:GetUser
      - iam:GetUserPolicy
      - iam:ListAccessKeys
      resource: "*"
  ...
```

6. Create YAML files for secrets in the **openshift-install** manifests directory that you generated previously. The secrets must be stored using the namespace and secret name defined in the **spec.secretRef** for each **CredentialsRequest** object.

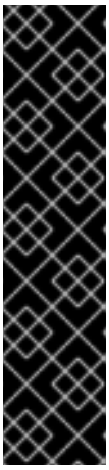
Sample CredentialsRequest object with secrets

```
apiVersion: cloudcredential.openshift.io/v1
kind: CredentialsRequest
metadata:
  name: <component-credentials-request>
  namespace: openshift-cloud-credential-operator
  ...
spec:
  providerSpec:
    apiVersion: cloudcredential.openshift.io/v1
    kind: AWSProviderSpec
    statementEntries:
    - effect: Allow
      action:
      - s3:CreateBucket
```

```
      - s3:DeleteBucket
      resource: "*"
      ...
  secretRef:
    name: <component-secret>
    namespace: <component-namespace>
  ...
```

Sample Secret object

```
apiVersion: v1
kind: Secret
metadata:
  name: <component-secret>
  namespace: <component-namespace>
data:
  aws_access_key_id: <base64_encoded_aws_access_key_id>
  aws_secret_access_key: <base64_encoded_aws_secret_access_key>
```



IMPORTANT

The release image includes **CredentialsRequest** objects for Technology Preview features that are enabled by the **TechPreviewNoUpgrade** feature set. You can identify these objects by their use of the **release.openshift.io/feature-gate: TechPreviewNoUpgrade** annotation.

- If you are not using any of these features, do not create secrets for these objects. Creating secrets for Technology Preview features that you are not using can cause the installation to fail.
- If you are using any of these features, you must create secrets for the corresponding objects.

- To find **CredentialsRequest** objects with the **TechPreviewNoUpgrade** annotation, run the following command:

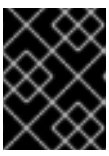
```
$ grep "release.openshift.io/feature-gate" *
```

Example output

```
0000_30_capi-operator_00_credentials-request.yaml:  release.openshift.io/feature-gate:
TechPreviewNoUpgrade
```

7. From the directory that contains the installation program, proceed with your cluster creation:

```
$ openshift-install create cluster --dir <installation_directory>
```



IMPORTANT

Before upgrading a cluster that uses manually maintained credentials, you must ensure that the CCO is in an upgradeable state.

Additional resources

- Updating a cluster using the web console
- Updating a cluster using the CLI

5.3.3. Mint mode

Mint mode is the default Cloud Credential Operator (CCO) credentials mode for OpenShift Container Platform on platforms that support it. In this mode, the CCO uses the provided administrator-level cloud credential to run the cluster. Mint mode is supported for AWS and GCP.

In mint mode, the **admin** credential is stored in the **kube-system** namespace and then used by the CCO to process the **CredentialsRequest** objects in the cluster and create users for each with specific permissions.

The benefits of mint mode include:

- Each cluster component has only the permissions it requires
- Automatic, on-going reconciliation for cloud credentials, including additional credentials or permissions that might be required for upgrades

One drawback is that mint mode requires **admin** credential storage in a cluster **kube-system** secret.

5.3.4. Mint mode with removal or rotation of the administrator-level credential

Currently, this mode is only supported on AWS and GCP.

In this mode, a user installs OpenShift Container Platform with an administrator-level credential just like the normal mint mode. However, this process removes the administrator-level credential secret from the cluster post-installation.

The administrator can have the Cloud Credential Operator make its own request for a read-only credential that allows it to verify if all **CredentialsRequest** objects have their required permissions, thus the administrator-level credential is not required unless something needs to be changed. After the associated credential is removed, it can be deleted or deactivated on the underlying cloud, if desired.

NOTE

Prior to a non z-stream upgrade, you must reinstate the credential secret with the administrator-level credential. If the credential is not present, the upgrade might be blocked.

The administrator-level credential is not stored in the cluster permanently.

Following these steps still requires the administrator-level credential in the cluster for brief periods of time. It also requires manually re-instating the secret with administrator-level credentials for each upgrade.

5.3.5. Next steps

- Install an OpenShift Container Platform cluster:

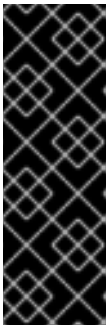
- Installing a cluster quickly on AWS with default options on installer-provisioned infrastructure
- Install a cluster with cloud customizations on installer-provisioned infrastructure
- Install a cluster with network customizations on installer-provisioned infrastructure
- Installing a cluster on user-provisioned infrastructure in AWS by using CloudFormation templates

5.4. INSTALLING A CLUSTER QUICKLY ON AWS

In OpenShift Container Platform version 4.11, you can install a cluster on Amazon Web Services (AWS) that uses the default configuration options.

5.4.1. Prerequisites

- You reviewed details about the OpenShift Container Platform installation and update processes.
- You read the documentation on selecting a cluster installation method and preparing it for users.
- You configured an AWS account to host the cluster.



IMPORTANT

If you have an AWS profile stored on your computer, it must not use a temporary session token that you generated while using a multi-factor authentication device. The cluster continues to use your current AWS credentials to create AWS resources for the entire life of the cluster, so you must use key-based, long-lived credentials. To generate appropriate keys, see Managing Access Keys for IAM Users in the AWS documentation. You can supply the keys when you run the installation program.

- If you use a firewall, you configured it to allow the sites that your cluster requires access to.
- If the cloud identity and access management (IAM) APIs are not accessible in your environment, or if you do not want to store an administrator-level credential secret in the **kube-system** namespace, you can manually create and maintain IAM credentials. Manual mode can also be used in environments where the cloud IAM APIs are not reachable.

5.4.2. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.11, you require access to the internet to install your cluster.

You must have internet access to:

- Access OpenShift Cluster Manager Hybrid Cloud Console to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access Quay.io to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.

IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

5.4.3. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the **~/.ssh/authorized_keys** list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The **./openshift-install gather** command also requires the SSH public key to be in place on the cluster nodes.

IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.

NOTE

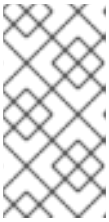
You must use a local key, not one that you configured with platform-specific approaches such as AWS key pairs.

Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N '' -f <path>/<file_name> 1
```

1 Specify the path and file name, such as **~/.ssh/id_ed25519**, of the new SSH key. If you have an existing key pair, ensure your public key is in the your **~/.ssh** directory.



NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS validated or Modules In Process cryptographic libraries on the **x86_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the ~/**.ssh/id_ed25519.pub** public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the **./openshift-install gather** command.

NOTE

On some distributions, default SSH private key identities such as ~/**.ssh/id_rsa** and ~/**.ssh/id_dsa** are managed automatically.

a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

Example output

```
Agent pid 31874
```

NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> (1)
```

(1) Specify the path and file name for your SSH private key, such as ~/**.ssh/id_ed25519**

Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

5.4.4. Obtaining the installation program

Before you install OpenShift Container Platform, download the installation file on a local computer.

Prerequisites

- You have a computer that runs Linux or macOS, with 500 MB of local disk space.

Procedure

1. Access the Infrastructure Provider page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program that corresponds with your host operating system and architecture, and place the file in the directory where you will store the installation configuration files.

IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.

IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation pull secret from the Red Hat OpenShift Cluster Manager . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

5.4.5. Deploying the cluster

You can install OpenShift Container Platform on a compatible cloud platform.

IMPORTANT

You can run the **create cluster** command of the installation program only once, during initial installation.

Prerequisites

- Configure an account with the cloud platform that hosts your cluster.
- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.

Procedure

1. Change to the directory that contains the installation program and initialize the cluster deployment:

```
$ ./openshift-install create cluster --dir <installation_directory> \ 1
    --log-level=info 2
```

1 For **<installation_directory>**, specify the directory name to store the files that the installation program creates.

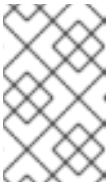
2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

When specifying the directory:

- Verify that the directory has the **execute** permission. This permission is required to run Terraform binaries under the installation directory.
- Use an empty directory. Some installation assets, such as bootstrap X.509 certificates, have short expiration intervals, therefore you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

2. Provide values at the prompts:

   a. Optional: Select an SSH key to use to access your cluster machines.

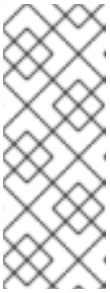


NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

   b. Select **aws** as the platform to target.

   c. If you do not have an Amazon Web Services (AWS) profile stored on your computer, enter the AWS access key ID and secret access key for the user that you configured to run the installation program.



NOTE

The AWS access key ID and secret access key are stored in **~/.aws/credentials** in the home directory of the current user on the installation host. You are prompted for the credentials by the installation program if the credentials for the exported profile are not present in the file. Any credentials that you provide to the installation program are stored in the file.

   d. Select the AWS region to deploy the cluster to.

   e. Select the base domain for the Route 53 service that you configured for your cluster.

f. Enter a descriptive name for your cluster.

g. Paste the pull secret from the Red Hat OpenShift Cluster Manager .

NOTE

If the cloud provider account that you configured on your host does not have sufficient permissions to deploy the cluster, the installation process stops, and the missing permissions are displayed.

3. Optional: Remove or disable the **AdministratorAccess** policy from the IAM account that you used to install the cluster.

NOTE

The elevated permissions provided by the **AdministratorAccess** policy are required only during installation.

Verification

When the cluster deployment completes successfully:

- The terminal displays directions for accessing your cluster, including a link to the web console and credentials for the **kubeadmin** user.
- Credential information also outputs to **<installation_directory>/.openshift_install.log**.

IMPORTANT

Do not delete the installation program or the files that the installation program creates. Both are required to delete the cluster.

Example output

```
...
INFO Install complete!
INFO To access the cluster as the system:admin user when using 'oc', run 'export
KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
INFO Access the OpenShift web-console here: https://console-openshift-
console.apps.mycluster.example.com
INFO Login to the console with user: "kubeadmin", and password: "password"
INFO Time elapsed: 36m22s
```

IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

Additional resources

- See Configuration and credential file settings in the AWS documentation for more information about AWS profile and credential configuration.

5.4.6. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.

IMPORTANT

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.11. Download and install the new version of **oc**.

Installing the OpenShift CLI on Linux
You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the architecture in the **Product Variant** drop-down menu.
3. Select the appropriate version in the **Version** drop-down menu.
4. Click **Download Now** next to the **OpenShift v4.11 Linux Client** entry and save the file.
5. Unpack the archive:

```
$ tar xvf <file>
```

6. Place the **oc** binary in a directory that is on your **PATH**.
   To check your **PATH**, execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.
   To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
C:\> oc <command>
```

Installing the OpenShift CLI on macOS

You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 macOS Client** entry and save the file.

NOTE

For macOS arm64, choose the **OpenShift v4.11 macOS arm64 Client** entry.

4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your PATH.
   To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

5.4.7. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

Example output

```
system:admin
```

5.4.8. Logging in to the cluster by using the web console

The **kubeadmin** user exists by default after an OpenShift Container Platform installation. You can log in to your cluster as the **kubeadmin** user by using the OpenShift Container Platform web console.

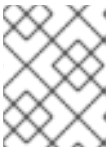
Prerequisites

- You have access to the installation host.
- You completed a cluster installation and all cluster Operators are available.

Procedure

1. Obtain the password for the **kubeadmin** user from the **kubeadmin-password** file on the installation host:

```
$ cat <installation_directory>/auth/kubeadmin-password
```



NOTE

Alternatively, you can obtain the **kubeadmin** password from the **<installation_directory>/.openshift_install.log** log file on the installation host.

2. List the OpenShift Container Platform web console route:

```
$ oc get routes -n openshift-console | grep 'console-openshift'
```

NOTE

Alternatively, you can obtain the OpenShift Container Platform route from the **<installation_directory>/.openshift_install.log** log file on the installation host.

Example output

```
console     console-openshift-console.apps.<cluster_name>.<base_domain>           console
https   reencrypt/Redirect   None
```

3. Navigate to the route detailed in the output of the preceding command in a web browser and log in as the **kubeadmin** user.

Additional resources

- See Accessing the web console for more details about accessing and understanding the OpenShift Container Platform web console.

5.4.9. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.11, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to OpenShift Cluster Manager Hybrid Cloud Console.

After you confirm that your OpenShift Cluster Manager Hybrid Cloud Console inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, use subscription watch to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

Additional resources

- See About remote health monitoring for more information about the Telemetry service

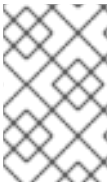
5.4.10. Next steps

- Validating an installation.
- Customize your cluster.
- If necessary, you can opt out of remote health reporting .

- If necessary, you can remove cloud provider credentials.

5.5. INSTALLING A CLUSTER ON AWS WITH CUSTOMIZATIONS

In OpenShift Container Platform version 4.11, you can install a customized cluster on infrastructure that the installation program provisions on Amazon Web Services (AWS). To customize the installation, you modify parameters in the **install-config.yaml** file before you install the cluster.

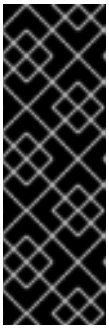


NOTE

The scope of the OpenShift Container Platform installation configurations is intentionally narrow. It is designed for simplicity and ensured success. You can complete many more OpenShift Container Platform configuration tasks after an installation completes.

5.5.1. Prerequisites

- You reviewed details about the OpenShift Container Platform installation and update processes.
- You read the documentation on selecting a cluster installation method and preparing it for users.
- You configured an AWS account to host the cluster.



IMPORTANT

If you have an AWS profile stored on your computer, it must not use a temporary session token that you generated while using a multi-factor authentication device. The cluster continues to use your current AWS credentials to create AWS resources for the entire life of the cluster, so you must use long-lived credentials. To generate appropriate keys, see Managing Access Keys for IAM Users in the AWS documentation. You can supply the keys when you run the installation program.

- If you use a firewall, you configured it to allow the sites that your cluster requires access to.
- If the cloud identity and access management (IAM) APIs are not accessible in your environment, or if you do not want to store an administrator-level credential secret in the **kube-system** namespace, you can manually create and maintain IAM credentials.

5.5.2. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.11, you require access to the internet to install your cluster.

You must have internet access to:

- Access OpenShift Cluster Manager Hybrid Cloud Console to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access Quay.io to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.

IMPORTANT

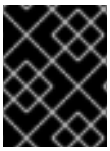
If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

5.5.3. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the **~/.ssh/authorized_keys** list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The **./openshift-install gather** command also requires the SSH public key to be in place on the cluster nodes.



IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.

NOTE

You must use a local key, not one that you configured with platform-specific approaches such as AWS key pairs.

Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N '' -f <path>/<file_name> 1
```

1 Specify the path and file name, such as **~/.ssh/id_ed25519**, of the new SSH key. If you have an existing key pair, ensure your public key is in the your **~/.ssh** directory.

NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS validated or Modules In Process cryptographic libraries on the **x86_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the ~/**.ssh/id_ed25519.pub** public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the **./openshift-install gather** command.

NOTE

On some distributions, default SSH private key identities such as ~/**.ssh/id_rsa** and ~/**.ssh/id_dsa** are managed automatically.

a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

Example output

```
Agent pid 31874
```

NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> (1)
```

(1) Specify the path and file name for your SSH private key, such as ~/**.ssh/id_ed25519**

Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

5.5.4. Obtaining an AWS Marketplace image

If you are deploying an OpenShift Container Platform cluster using an AWS Marketplace image, you must first subscribe through AWS. Subscribing to the offer provides you with the AMI ID that the installation program uses to deploy worker nodes.

Prerequisites

- You have an AWS account to purchase the offer. This account does not have to be the same account that is used to install the cluster.

Procedure

1. Complete the OpenShift Container Platform subscription from the AWS Marketplace.
2. Record the AMI ID for your specific region. As part of the installation process, you must update the **install-config.yaml** file with this value before deploying the cluster.

Sample install-config.yaml file with AWS Marketplace worker nodes

```
apiVersion: v1
baseDomain: example.com
compute:
- hyperthreading: Enabled
  name: worker
  platform:
    aws:
      amiID: ami-06c4d345f7c207239 (1)
      type: m5.4xlarge
  replicas: 3
metadata:
  name: test-cluster
platform:
  aws:
    region: us-east-2 (2)
sshKey: ssh-ed25519 AAAA...
pullSecret: '{"auths": ...}'
```

(1) The AMI ID from your AWS Marketplace subscription.

(2) Your AMI ID is associated with a specific AWS region. When creating the installation configuration file, ensure that you select the same AWS region that you specified when configuring your subscription.

5.5.5. Obtaining the installation program

Before you install OpenShift Container Platform, download the installation file on a local computer.

Prerequisites

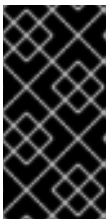
- You have a computer that runs Linux or macOS, with 500 MB of local disk space.

Procedure

1. Access the Infrastructure Provider page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.

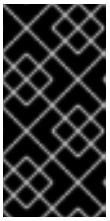
2. Select your infrastructure provider.

3. Navigate to the page for your installation type, download the installation program that corresponds with your host operating system and architecture, and place the file in the directory where you will store the installation configuration files.



IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.



IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation pull secret from the Red Hat OpenShift Cluster Manager . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

5.5.6. Creating the installation configuration file

You can customize the OpenShift Container Platform cluster you install on Amazon Web Services (AWS).

Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.
- Obtain service principal permissions at the subscription level.

Procedure

1. Create the **install-config.yaml** file.

   a. Change to the directory that contains the installation program and run the following command:

```
$ ./openshift-install create install-config --dir <installation_directory> 1
```

1 For **<installation_directory>**, specify the directory name to store the files that the installation program creates.

When specifying the directory:

- Verify that the directory has the **execute** permission. This permission is required to run Terraform binaries under the installation directory.
- Use an empty directory. Some installation assets, such as bootstrap X.509 certificates, have short expiration intervals, therefore you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

b. At the prompts, provide the configuration details for your cloud:

i. Optional: Select an SSH key to use to access your cluster machines.

NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

ii. Select **AWS** as the platform to target.

iii. If you do not have an Amazon Web Services (AWS) profile stored on your computer, enter the AWS access key ID and secret access key for the user that you configured to run the installation program.

iv. Select the AWS region to deploy the cluster to.

v. Select the base domain for the Route 53 service that you configured for your cluster.

vi. Enter a descriptive name for your cluster.

vii. Paste the pull secret from the Red Hat OpenShift Cluster Manager .

2. Modify the **install-config.yaml** file. You can find more information about the available parameters in the "Installation configuration parameters" section.

3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.

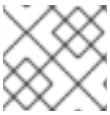
IMPORTANT

The **install-config.yaml** file is consumed during the installation process. If you want to reuse the file, you must back it up now.

5.5.6.1. Installation configuration parameters

Before you deploy an OpenShift Container Platform cluster, you provide parameter values to describe your account on the cloud platform that hosts your cluster and optionally customize your cluster's platform. When you create the **install-config.yaml** installation configuration file, you provide values for

the required parameters through the command line. If you customize your cluster, you can modify the **install-config.yaml** file to provide more details about the platform.



NOTE

After installation, you cannot modify these parameters in the **install-config.yaml** file.

5.5.6.1.1. Required configuration parameters

Required installation configuration parameters are described in the following table:

Table 5.1. Required parameters

Parameter	Description	Values
apiVersion	The API version for the **install-config.yaml** content. The current version is **v1**. The installer may also support older API versions.	String
baseDomain	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the **baseDomain** and **metadata.name** parameter values that uses the **<metadata.name>.<baseDomain>** format.	A fully-qualified domain or subdomain name, such as **example.com**.
metadata	Kubernetes resource **ObjectMeta**, from which only the **name** parameter is consumed.	Object
metadata.name	The name of the cluster. DNS records for the cluster are all subdomains of **{{.metadata.name}}.{{.baseDomain}}**.	String of lowercase letters, hyphens (**-**), and periods (**.**), such as **dev**.

Parameter	Description	Values
platform	The configuration for the specific platform upon which to perform the installation: **alibabacloud**, **aws**, **baremetal**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**. For additional information about **platform.<platform>** parameters, consult the table for your specific platform that follows.	Object
pullSecret	Get a pull secret from the Red Hat OpenShift Cluster Manager to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	<pre>{ "auths":{ "cloud.openshift.com":{ "auth":"b3Blb=", "email":"you@example.com" }, "quay.io":{ "auth":"b3Blb=", "email":"you@example.com" } } }</pre>

5.5.6.1.2. Network configuration parameters

You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

Only IPv4 addresses are supported.

NOTE

Globalnet is not supported with Red Hat OpenShift Data Foundation disaster recovery solutions. For regional disaster recovery scenarios, ensure that you use a nonoverlapping range of private IP addresses for the cluster and service networks in each cluster.

Table 5.2. Network parameters

Parameter	Description	Values

Parameter	Description	Values
networking	The configuration for the cluster network.	Object  **NOTE** You cannot modify parameters specified by the **networking** object after installation.
networking.networkType	The cluster network provider Container Network Interface (CNI) cluster network provider to install.	Either **OpenShiftSDN** or **OVNKubernetes**. **OpenShiftSDN** is a CNI provider for all-Linux networks. **OVNKubernetes** is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is **OpenShiftSDN**.
networking.clusterNetwork	The IP address blocks for pods. The default value is **10.128.0.0/14** with a host prefix of **/23**. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: `networking:` `  clusterNetwork:` `  - cidr: 10.128.0.0/14` `    hostPrefix: 23`
networking.clusterNetwork.cidr	Required if you use **networking.clusterNetwork**. An IP address block. An IPv4 network.	An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between **0** and **32**.
networking.clusterNetwork.hostPrefix	The subnet prefix length to assign to each individual node. For example, if **hostPrefix** is set to **23** then each node is assigned a **/23** subnet out of the given **cidr**. A **hostPrefix** value of **23** provides 510 (2^(32 - 23) - 2) pod IP addresses.	A subnet prefix. The default value is **23**.
networking.serviceNetwork	The IP address block for services. The default value is **172.30.0.0/16**. The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.	An array with an IP address block in CIDR format. For example: `networking:` `  serviceNetwork:` `  - 172.30.0.0/16`

Parameter	Description	Values
networking.machineNetwork	The IP address blocks for machines. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: `networking:` `  machineNetwork:` `  - cidr: 10.0.0.0/16`
networking.machineNetwork.cidr	Required if you use **networking.machineNetwork**. An IP address block. The default value is **10.0.0.0/16** for all platforms other than libvirt. For libvirt, the default value is **192.168.126.0/24**.	An IP network block in CIDR notation. For example, **10.0.0.0/16**. **NOTE** Set the **networking.machineNetwork** to match the CIDR that the preferred NIC resides in.

5.5.6.1.3. Optional configuration parameters

Optional installation configuration parameters are described in the following table:

Table 5.3. Optional parameters

Parameter	Description	Values
additionalTrustBundle	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String
capabilities	Controls the installation of optional core cluster components. You can reduce the footprint of your OpenShift Container Platform cluster by disabling optional components.	String array

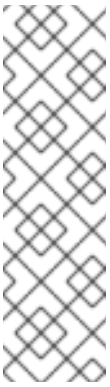
Parameter	Description	Values
capabilities.baselineCapabilitySet	Selects an initial set of optional capabilities to enable. Valid values are **None**, **v4.11** and **vCurrent**. **v4.11** enables the **baremetal** Operator, the **marketplace** Operator, and the **openshift-samples** content. **vCurrent** installs the recommended set of capabilities for the current version of OpenShift Container Platform. The default value is **vCurrent**.	String
capabilities.additionalEnabledCapabilities	Extends the set of optional capabilities beyond what you specify in **baselineCapabilitySet**. Valid values are **baremetal**, **marketplace** and **openshift-samples**. You may specify multiple capabilities in this parameter.	String array
cgroupsV2	Enables Linux control groups version 2 (cgroups v2) on specific nodes in your cluster. The OpenShift Container Platform process for enabling cgroups v2 disables all cgroup version 1 controllers and hierarchies. The OpenShift Container Platform cgroups version 2 feature is in Developer Preview and is not supported by Red Hat at this time.	**true**
compute	The configuration for the machines that comprise the compute nodes.	Array of **MachinePool** objects.
compute.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** and **arm64**. Not all installation options support the 64-bit ARM architecture. To verify if your installation option is supported on your platform, see *Supported installation methods for different platforms* in *Selecting a cluster installation method and preparing it for users*.	String

Parameter	Description	Values
compute.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  **IMPORTANT** If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
compute.name	Required if you use **compute**. The name of the machine pool.	**worker**
compute.platform	Required if you use **compute**. Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the **controlPlane.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
compute.replicas	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to **2**. The default value is **3**.
controlPlane	The configuration for the machines that comprise the control plane.	Array of **MachinePool** objects.
controlPlane.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** and **arm64**. Not all installation options support the 64-bit ARM architecture. To verify if your installation option is supported on your platform, see *Supported installation methods for different platforms* in *Selecting a cluster installation method and preparing it for users*.	String

Parameter	Description	Values
controlPlane.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  **IMPORTANT** If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
controlPlane.name	Required if you use **controlPlane**. The name of the machine pool.	**master**
controlPlane.platform	Required if you use **controlPlane**. Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the **compute.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
controlPlane.replicas	The number of control plane machines to provision.	The only supported value is **3**, which is the default value.

Parameter	Description	Values
credentialsMode	The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported.  **NOTE** Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the *Cloud Credential Operator* entry in the *Cluster Operators reference* content.  **NOTE** If your AWS account has service control policies (SCP) enabled, you must configure the **credentialsMode** parameter to **Mint**, **Passthrough** or **Manual**.	**Mint**, **Passthrough**, **Manual** or an empty string (**""**).

Parameter	Description	Values
fips	Enable or disable FIPS mode. The default is **false** (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.  **IMPORTANT** To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.  **NOTE** If you are using Azure File storage, you cannot enable FIPS mode.	**false** or **true**
imageContentSources	Sources and repositories for the release-image content.	Array of objects. Includes a **source** and, optionally, **mirrors**, as described in the following rows of this table.
imageContentSources.source	Required if you use **imageContentSources**. Specify the repository that users refer to, for example, in image pull specifications.	String

Parameter	Description	Values
imageContentSources.mirrors	Specify one or more repositories that may also contain the same images.	Array of strings
publish	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	**Internal** or **External**. To deploy a private cluster, which cannot be accessed from the internet, set **publish** to **Internal**. The default value is **External**.
sshKey	The SSH key to authenticate access to your cluster machines.  **NOTE** For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.	For example, **sshKey: ssh-ed25519 AAAA..**.

5.5.6.1.4. Optional AWS configuration parameters

Optional AWS configuration parameters are described in the following table:

Table 5.4. Optional AWS parameters

Parameter	Description	Values
compute.platform.aws.amiID	The AWS AMI used to boot compute machines for the cluster. This is required for regions that require a custom RHCOS AMI.	Any published or custom RHCOS AMI that belongs to the set AWS region. See *RHCOS AMIs for AWS infrastructure* for available AMI IDs.

Parameter	Description	Values
compute.platform.aws.iamRole	A pre-existing AWS IAM role applied to the compute machine pool instance profiles. You can use these fields to match naming schemes and include predefined permissions boundaries for your IAM roles. If undefined, the installation program creates a new IAM role.	The name of a valid AWS IAM role.
compute.platform.aws.rootVolume.iops	The Input/Output Operations Per Second (IOPS) that is reserved for the root volume.	Integer, for example **4000**.
compute.platform.aws.rootVolume.size	The size in GiB of the root volume.	Integer, for example **500**.
compute.platform.aws.rootVolume.type	The type of the root volume.	Valid AWS EBS volume type, such as **io1**.
compute.platform.aws.rootVolume.kmsKeyARN	The Amazon Resource Name (key ARN) of a KMS key. This is required to encrypt OS volumes of worker nodes with a specific KMS key.	Valid key ID or the key ARN
compute.platform.aws.type	The EC2 instance type for the compute machines.	Valid AWS instance type, such as **m4.2xlarge**. See the **Supported AWS machine types** table that follows.
compute.platform.aws.zones	The availability zones where the installation program creates machines for the compute machine pool. If you provide your own VPC, you must provide a subnet in that availability zone.	A list of valid AWS availability zones, such as **us-east-1c**, in a YAML sequence.

Parameter	Description	Values
compute.aws.region	The AWS region that the installation program creates compute resources in.	Any valid AWS region, such as **us-east-1**. You can use the AWS CLI to access the regions available based on your selected instance type. For example: `aws ec2 describe-instance-type-offerings --filters Name=instance-type,Values=c7g.xlarge`  **IMPORTANT** When running on ARM based AWS instances, ensure that you enter a region where AWS Graviton processors are available. See Global availability map in the AWS documentation. Currently, AWS Graviton3 processors are only available in some regions.
controlPlane.platform.aws.amiID	The AWS AMI used to boot control plane machines for the cluster. This is required for regions that require a custom RHCOS AMI.	Any published or custom RHCOS AMI that belongs to the set AWS region. See *RHCOS AMIs for AWS infrastructure* for available AMI IDs.
controlPlane.platform.aws.iamRole	A pre-existing AWS IAM role applied to the control plane machine pool instance profiles. You can use these fields to match naming schemes and include predefined permissions boundaries for your IAM roles. If undefined, the installation program creates a new IAM role.	The name of a valid AWS IAM role.
controlPlane.platform.aws.rootVolume.kmsKeyARN	The Amazon Resource Name (key ARN) of a KMS key. This is required to encrypt OS volumes of control plane nodes with a specific KMS key.	Valid key ID and the key ARN.
controlPlane.platform.aws.type	The EC2 instance type for the control plane machines.	Valid AWS instance type, such as **m6i.xlarge**. See the **Supported AWS machine types** table that follows.

Parameter	Description	Values
controlPlane.platform.aws.zones	The availability zones where the installation program creates machines for the control plane machine pool.	A list of valid AWS availability zones, such as **us-east-1c**, in a YAML sequence.
controlPlane.aws.region	The AWS region that the installation program creates control plane resources in.	Valid AWS region, such as **us-east-1**.
platform.aws.amiID	The AWS AMI used to boot all machines for the cluster. If set, the AMI must belong to the same region as the cluster. This is required for regions that require a custom RHCOS AMI.	Any published or custom RHCOS AMI that belongs to the set AWS region. See *RHCOS AMIs for AWS infrastructure* for available AMI IDs.
platform.aws.hostedZone	An existing Route 53 private hosted zone for the cluster. You can only use a pre-existing hosted zone when also supplying your own VPC. The hosted zone must already be associated with the user-provided VPC before installation. Also, the domain of the hosted zone must be the cluster domain or a parent of the cluster domain. If undefined, the installation program creates a new hosted zone.	String, for example **Z3URY6TWQ91KVV**.
platform.aws.serviceEndpoints.name	The AWS service endpoint name. Custom endpoints are only required for cases where alternative AWS endpoints, like FIPS, must be used. Custom API endpoints can be specified for EC2, S3, IAM, Elastic Load Balancing, Tagging, Route 53, and STS AWS services.	Valid AWS service endpoint name.
platform.aws.serviceEndpoints.url	The AWS service endpoint URL. The URL must use the **https** protocol and the host must trust the certificate.	Valid AWS service endpoint URL.

Parameter	Description	Values
platform.aws.userTags	A map of keys and values that the installation program adds as tags to all resources that it creates.	Any valid YAML map, such as key value pairs in the **<key>: <value>** format. For more information about AWS tags, see Tagging Your Amazon EC2 Resources in the AWS documentation.
platform.aws.subnets	If you provide the VPC instead of allowing the installation program to create the VPC for you, specify the subnet for the cluster to use. The subnet must be part of the same **machineNetwork[].cidr** ranges that you specify. For a standard cluster, specify a public and a private subnet for each availability zone. For a private cluster, specify a private subnet for each availability zone.	Valid subnet IDs.

5.5.6.2. Minimum resource requirements for cluster installation

Each cluster machine must meet the following minimum requirements:

Table 5.5. Minimum resource requirements

Machine	Operating System	vCPU [1]	Virtual RAM	Storage	IOPS [2]
Bootstrap	RHCOS	4	16 GB	100 GB	300
Control plane	RHCOS	4	16 GB	100 GB	300
Compute	RHCOS, RHEL 8.6 and later [3]	2	8 GB	100 GB	300

1. One vCPU is equivalent to one physical core when simultaneous multithreading (SMT), or hyperthreading, is not enabled. When enabled, use the following formula to calculate the corresponding ratio: (threads per core × cores) × sockets = vCPUs.

2. OpenShift Container Platform and Kubernetes are sensitive to disk performance, and faster storage is recommended, particularly for etcd on the control plane nodes which require a 10 ms p99 fsync duration. Note that on many cloud platforms, storage size and IOPS scale together, so you might need to over-allocate storage volume to obtain sufficient performance.

3. As with all user-provisioned installations, if you choose to use RHEL compute machines in your cluster, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks.

Use of RHEL 7 compute machines is deprecated and has been removed in OpenShift Container Platform 4.10 and later.

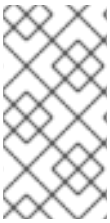
If an instance type for your platform meets the minimum requirements for cluster machines, it is supported to use in OpenShift Container Platform.

Additional resources

- Optimizing storage

5.5.6.3. Tested instance types for AWS

The following Amazon Web Services (AWS) instance types have been tested with OpenShift Container Platform.



NOTE

Use the machine types included in the following charts for your AWS instances. If you use an instance type that is not listed in the chart, ensure that the instance size you use matches the minimum resource requirements that are listed in "Minimum resource requirements for cluster installation".

Example 5.16. Machine types based on 64-bit x86 architecture

- **c4.***
- **c5.***
- **c5a.***
- **i3.***
- **m4.***
- **m5.***
- **m5a.***
- **m6a.***
- **m6i.***
- **r4.***
- **r5.***
- **r5a.***
- **r6i.***
- **t3.***
- **t3a.***

5.5.6.4. Tested instance types for AWS on 64-bit ARM infrastructures

The following Amazon Web Services (AWS) ARM64 instance types have been tested with OpenShift Container Platform.

NOTE

Use the machine types included in the following charts for your AWS ARM instances. If you use an instance type that is not listed in the chart, ensure that the instance size you use matches the minimum resource requirements that are listed in "Minimum resource requirements for cluster installation".

Example 5.17. Machine types based on 64-bit ARM architecture

- **c6g.***
- **m6g.***

5.5.6.5. Sample customized install-config.yaml file for AWS

You can customize the installation configuration file (**install-config.yaml**) to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.

IMPORTANT

This sample YAML file is provided for reference only. You must obtain your **install-config.yaml** file by using the installation program and modify it.

```
apiVersion: v1
baseDomain: example.com (1)
credentialsMode: Mint (2)
controlPlane: (3) (4)
  hyperthreading: Enabled (5)
  name: master
  platform:
    aws:
      zones:
      - us-west-2a
      - us-west-2b
      rootVolume:
        iops: 4000
        size: 500
        type: io1 (6)
      metadataService:
        authentication: Optional (7)
      type: m6i.xlarge
  replicas: 3
compute: (8)
- hyperthreading: Enabled (9)
  name: worker
  platform:
    aws:
```

```
      rootVolume:
        iops: 2000
        size: 500
        type: io1 10
      metadataService:
        authentication: Optional 11
      type: c5.4xlarge
      zones:
      - us-west-2c
  replicas: 3
metadata:
  name: test-cluster 12
networking:
  clusterNetwork:
  - cidr: 10.128.0.0/14
    hostPrefix: 23
  machineNetwork:
  - cidr: 10.0.0.0/16
  networkType: OpenShiftSDN
  serviceNetwork:
  - 172.30.0.0/16
platform:
  aws:
    region: us-west-2 13
    userTags:
      adminContact: jdoe
      costCenter: 7536
    amiID: ami-96c6f8f7 14
    serviceEndpoints: 15
      - name: ec2
        url: https://vpce-id.ec2.us-west-2.vpce.amazonaws.com
fips: false 16
sshKey: ssh-ed25519 AAAA... 17
pullSecret: '{"auths": ...}' 18
```

1 12 13 18 Required. The installation program prompts you for this value.

2 Optional: Add this parameter to force the Cloud Credential Operator (CCO) to use the specified mode, instead of having the CCO dynamically try to determine the capabilities of the credentials. For details about CCO modes, see the *Cloud Credential Operator* entry in the *Red Hat Operators reference* content.

3 8 If you do not provide these parameters and values, the installation program provides the default value.

4 The **controlPlane** section is a single mapping, but the **compute** section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, **-**, and the first line of the **controlPlane** section must not. Only one control plane pool is used.

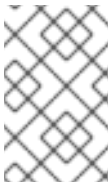
5 9 Whether to enable or disable simultaneous multithreading, or **hyperthreading**. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores. You can disable it by setting the parameter value to **Disabled**. If you disable simultaneous multithreading in some cluster machines, you must disable it in all cluster machines.

IMPORTANT

If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance. Use larger instance types, such as **m4.2xlarge** or **m5.2xlarge**, for your machines if you disable simultaneous multithreading.

6 10 To configure faster storage for etcd, especially for larger clusters, set the storage type as **io1** and set **iops** to **2000**.

7 11 Whether to require the Amazon EC2 Instance Metadata Service v2 (IMDSv2). To require IMDSv2, set the parameter value to **Required**. To allow the use of both IMDSv1 and IMDSv2, set the parameter value to **Optional**. If no value is specified, both IMDSv1 and IMDSv2 are allowed.



NOTE

The IMDS configuration for control plane machines that is set during cluster installation can only be changed by using the AWS CLI. The IMDS configuration for compute machines can be changed by using machine sets.

14 The ID of the AMI used to boot machines for the cluster. If set, the AMI must belong to the same region as the cluster.

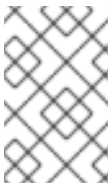
15 The AWS service endpoints. Custom endpoints are required when installing to an unknown AWS region. The endpoint URL must use the **https** protocol and the host must trust the certificate.

16 Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.

IMPORTANT

To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.

17 You can optionally provide the **sshKey** value that you use to access the machines in your cluster.



NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

5.5.6.6. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.

NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

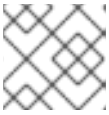
Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: ec2.<region>.amazonaws.com,elasticloadbalancing.
<region>.amazonaws.com,s3.<region>.amazonaws.com 3
additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
```

1. A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
2. A proxy URL to use for creating HTTPS connections outside the cluster.
3. A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use ***** to bypass the proxy for all destinations. If you have added the Amazon **EC2**,**Elastic Load Balancing**, and **S3** VPC endpoints to your VPC, you must add these endpoints to the **noProxy** field.
4. If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace that contains one or more additional CA certificates that are required for proxying HTTPS connections. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges these contents with the Red Hat

Enterprise Linux CoreOS (RHCOS) trust bundle, and this config map is referenced in the **trustedCA** field of the **Proxy** object. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.



NOTE

The installation program does not support the proxy **readinessEndpoints** field.

NOTE

If the installer times out, restart and then complete the deployment by using the **wait-for** command of the installer. For example:

```
$ ./openshift-install wait-for install-complete --log-level debug
```

2. Save the file and reference it when installing OpenShift Container Platform.

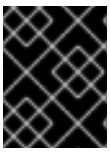
The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.

NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

5.5.7. Deploying the cluster

You can install OpenShift Container Platform on a compatible cloud platform.



IMPORTANT

You can run the **create cluster** command of the installation program only once, during initial installation.

Prerequisites

- Configure an account with the cloud platform that hosts your cluster.
- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.

Procedure

1. Change to the directory that contains the installation program and initialize the cluster deployment:

```
$ ./openshift-install create cluster --dir <installation_directory> \ 1
    --log-level=info 2
```

1. For **<installation_directory>**, specify the location of your customized **./install-config.yaml** file.
2. To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

NOTE

If the cloud provider account that you configured on your host does not have sufficient permissions to deploy the cluster, the installation process stops, and the missing permissions are displayed.

2. Optional: Remove or disable the **AdministratorAccess** policy from the IAM account that you used to install the cluster.

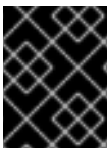
NOTE

The elevated permissions provided by the **AdministratorAccess** policy are required only during installation.

Verification

When the cluster deployment completes successfully:

- The terminal displays directions for accessing your cluster, including a link to the web console and credentials for the **kubeadmin** user.
- Credential information also outputs to **<installation_directory>/.openshift_install.log**.

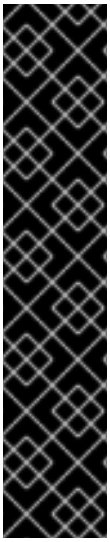


IMPORTANT

Do not delete the installation program or the files that the installation program creates. Both are required to delete the cluster.

Example output

```
...
INFO Install complete!
INFO To access the cluster as the system:admin user when using 'oc', run 'export
KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
INFO Access the OpenShift web-console here: https://console-openshift-
console.apps.mycluster.example.com
INFO Login to the console with user: "kubeadmin", and password: "password"
INFO Time elapsed: 36m22s
```



IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

5.5.8. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.

IMPORTANT

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.11. Download and install the new version of **oc**.

Installing the OpenShift CLI on Linux

You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the architecture in the **Product Variant** drop-down menu.
3. Select the appropriate version in the **Version** drop-down menu.
4. Click **Download Now** next to the **OpenShift v4.11 Linux Client** entry and save the file.
5. Unpack the archive:

```
$ tar xvf <file>
```

6. Place the **oc** binary in a directory that is on your **PATH**.
   To check your **PATH**, execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.
   To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
C:\> oc <command>
```

Installing the OpenShift CLI on macOS

You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 macOS Client** entry and save the file.

NOTE

For macOS arm64, choose the **OpenShift v4.11 macOS arm64 Client** entry.

4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your PATH.
   To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

5.5.9. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

Example output

```
system:admin
```

5.5.10. Logging in to the cluster by using the web console

The **kubeadmin** user exists by default after an OpenShift Container Platform installation. You can log in to your cluster as the **kubeadmin** user by using the OpenShift Container Platform web console.

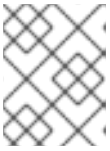
Prerequisites

- You have access to the installation host.
- You completed a cluster installation and all cluster Operators are available.

Procedure

1. Obtain the password for the **kubeadmin** user from the **kubeadmin-password** file on the installation host:

```
$ cat <installation_directory>/auth/kubeadmin-password
```

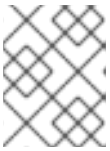


NOTE

Alternatively, you can obtain the **kubeadmin** password from the **<installation_directory>/.openshift_install.log** log file on the installation host.

2. List the OpenShift Container Platform web console route:

```
$ oc get routes -n openshift-console | grep 'console-openshift'
```



NOTE

Alternatively, you can obtain the OpenShift Container Platform route from the **<installation_directory>/.openshift_install.log** log file on the installation host.

Example output

```
console     console-openshift-console.apps.<cluster_name>.<base_domain>           console
https   reencrypt/Redirect   None
```

3. Navigate to the route detailed in the output of the preceding command in a web browser and log in as the **kubeadmin** user.

Additional resources

- See Accessing the web console for more details about accessing and understanding the OpenShift Container Platform web console.

5.5.11. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.11, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to OpenShift Cluster Manager Hybrid Cloud Console.

After you confirm that your OpenShift Cluster Manager Hybrid Cloud Console inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, use subscription watch to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

Additional resources

- See About remote health monitoring for more information about the Telemetry service.

5.5.12. Next steps

- Validating an installation.
- Customize your cluster.
- If necessary, you can opt out of remote health reporting .
- If necessary, you can remove cloud provider credentials.

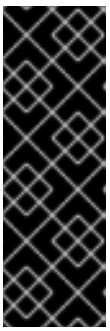
5.6. INSTALLING A CLUSTER ON AWS WITH NETWORK CUSTOMIZATIONS

In OpenShift Container Platform version 4.11, you can install a cluster on Amazon Web Services (AWS) with customized network configuration options. By customizing your network configuration, your cluster can coexist with existing IP address allocations in your environment and integrate with existing MTU and VXLAN configurations.

You must set most of the network configuration parameters during installation, and you can modify only **kubeProxy** configuration parameters in a running cluster.

5.6.1. Prerequisites

- You reviewed details about the OpenShift Container Platform installation and update processes.
- You read the documentation on selecting a cluster installation method and preparing it for users.
- You configured an AWS account to host the cluster.



IMPORTANT

If you have an AWS profile stored on your computer, it must not use a temporary session token that you generated while using a multi-factor authentication device. The cluster continues to use your current AWS credentials to create AWS resources for the entire life of the cluster, so you must use key-based, long-lived credentials. To generate appropriate keys, see Managing Access Keys for IAM Users in the AWS documentation. You can supply the keys when you run the installation program.

- If you use a firewall, you configured it to allow the sites that your cluster requires access to.
- If the cloud identity and access management (IAM) APIs are not accessible in your environment, or if you do not want to store an administrator-level credential secret in the **kube-system** namespace, you can manually create and maintain IAM credentials.

5.6.2. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.11, you require access to the internet to install your cluster.

You must have internet access to:

- Access OpenShift Cluster Manager Hybrid Cloud Console to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access Quay.io to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.

IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

5.6.3. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the **~/.ssh/authorized_keys** list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The **./openshift-install gather** command also requires the SSH public key to be in place on the cluster nodes.

IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.

NOTE

You must use a local key, not one that you configured with platform-specific approaches such as AWS key pairs.

Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N '' -f <path>/<file_name>
```
(1)

(1) Specify the path and file name, such as **~/.ssh/id_ed25519**, of the new SSH key. If you have an existing key pair, ensure your public key is in the your **~/.ssh** directory.

NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS validated or Modules In Process cryptographic libraries on the **x86_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the ~/**.ssh/id_ed25519.pub** public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the **./openshift-install gather** command.

NOTE

On some distributions, default SSH private key identities such as ~/**.ssh/id_rsa** and ~/**.ssh/id_dsa** are managed automatically.

a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

Example output

```
Agent pid 31874
```

NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

1 Specify the path and file name for your SSH private key, such as ~/**.ssh/id_ed25519**

Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

5.6.4. Obtaining the installation program

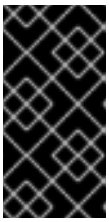
Before you install OpenShift Container Platform, download the installation file on a local computer.

Prerequisites

- You have a computer that runs Linux or macOS, with 500 MB of local disk space.

Procedure

1. Access the Infrastructure Provider page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program that corresponds with your host operating system and architecture, and place the file in the directory where you will store the installation configuration files.



IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.

IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation pull secret from the Red Hat OpenShift Cluster Manager . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

5.6.5. Network configuration phases

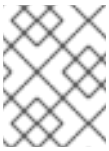
There are two phases prior to OpenShift Container Platform installation where you can customize the network configuration.

Phase 1

You can customize the following network-related fields in the **install-config.yaml** file before you create the manifest files:

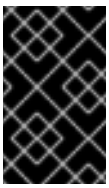
- **networking.networkType**
- **networking.clusterNetwork**
- **networking.serviceNetwork**
- **networking.machineNetwork**

For more information on these fields, refer to *Installation configuration parameters*.



NOTE

Set the **networking.machineNetwork** to match the CIDR that the preferred NIC resides in.



IMPORTANT

The CIDR range **172.17.0.0/16** is reserved by libVirt. You cannot use this range or any range that overlaps with this range for any networks in your cluster.

Phase 2

After creating the manifest files by running **openshift-install create manifests**, you can define a customized Cluster Network Operator manifest with only the fields you want to modify. You can use the manifest to specify advanced network configuration.

You cannot override the values specified in phase 1 in the **install-config.yaml** file during phase 2. However, you can further customize the cluster network provider during phase 2.

5.6.6. Creating the installation configuration file

You can customize the OpenShift Container Platform cluster you install on Amazon Web Services (AWS).

Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.
- Obtain service principal permissions at the subscription level.

Procedure

1. Create the **install-config.yaml** file.
   a. Change to the directory that contains the installation program and run the following command:

```
$ ./openshift-install create install-config --dir <installation_directory> 1
```

1 For **<installation_directory>**, specify the directory name to store the files that the installation program creates.

When specifying the directory:

- Verify that the directory has the **execute** permission. This permission is required to run Terraform binaries under the installation directory.
- Use an empty directory. Some installation assets, such as bootstrap X.509 certificates, have short expiration intervals, therefore you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them

into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

b. At the prompts, provide the configuration details for your cloud:

i. Optional: Select an SSH key to use to access your cluster machines.

NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

ii. Select **AWS** as the platform to target.

iii. If you do not have an Amazon Web Services (AWS) profile stored on your computer, enter the AWS access key ID and secret access key for the user that you configured to run the installation program.

iv. Select the AWS region to deploy the cluster to.

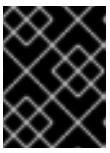
v. Select the base domain for the Route 53 service that you configured for your cluster.

vi. Enter a descriptive name for your cluster.

vii. Paste the pull secret from the Red Hat OpenShift Cluster Manager .

2. Modify the **install-config.yaml** file. You can find more information about the available parameters in the "Installation configuration parameters" section.

3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.



IMPORTANT

The **install-config.yaml** file is consumed during the installation process. If you want to reuse the file, you must back it up now.

5.6.6.1. Installation configuration parameters

Before you deploy an OpenShift Container Platform cluster, you provide parameter values to describe your account on the cloud platform that hosts your cluster and optionally customize your cluster's platform. When you create the **install-config.yaml** installation configuration file, you provide values for the required parameters through the command line. If you customize your cluster, you can modify the **install-config.yaml** file to provide more details about the platform.

NOTE

After installation, you cannot modify these parameters in the **install-config.yaml** file.

5.6.6.1.1. Required configuration parameters

Required installation configuration parameters are described in the following table:

Table 5.6. Required parameters

Parameter	Description	Values
apiVersion	The API version for the **install-config.yaml** content. The current version is **v1**. The installer may also support older API versions.	String
baseDomain	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the **baseDomain** and **metadata.name** parameter values that uses the **<metadata.name>.<baseDomain>** format.	A fully-qualified domain or subdomain name, such as **example.com**.
metadata	Kubernetes resource **ObjectMeta**, from which only the **name** parameter is consumed.	Object
metadata.name	The name of the cluster. DNS records for the cluster are all subdomains of **{{.metadata.name}}.{{.baseDomain}}**.	String of lowercase letters, hyphens (**-**), and periods (**.**), such as **dev**.
platform	The configuration for the specific platform upon which to perform the installation: **alibabacloud**, **aws**, **baremetal**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**. For additional information about **platform.<platform>** parameters, consult the table for your specific platform that follows.	Object

Parameter	Description	Values
pullSecret	Get a pull secret from the Red Hat OpenShift Cluster Manager to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	<pre>{ "auths":{ "cloud.openshift.com":{ "auth":"b3Blb=", "email":"you@example.com" }, "quay.io":{ "auth":"b3Blb=", "email":"you@example.com" } } }</pre>

5.6.6.1.2. Network configuration parameters

You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

Only IPv4 addresses are supported.

NOTE

Globalnet is not supported with Red Hat OpenShift Data Foundation disaster recovery solutions. For regional disaster recovery scenarios, ensure that you use a nonoverlapping range of private IP addresses for the cluster and service networks in each cluster.

Table 5.7. Network parameters

Parameter	Description	Values
networking	The configuration for the cluster network.	Object  **NOTE** You cannot modify parameters specified by the **networking** object after installation.

Parameter	Description	Values
networking.networkType	The cluster network provider Container Network Interface (CNI) cluster network provider to install.	Either **OpenShiftSDN** or **OVNKubernetes**. **OpenShiftSDN** is a CNI provider for all-Linux networks. **OVNKubernetes** is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is **OpenShiftSDN**.
networking.clusterNetwork	The IP address blocks for pods. The default value is **10.128.0.0/14** with a host prefix of **/23**. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: `networking:` `  clusterNetwork:` `  - cidr: 10.128.0.0/14` `  hostPrefix: 23`
networking.clusterNetwork.cidr	Required if you use **networking.clusterNetwork**. An IP address block. An IPv4 network.	An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between **0** and **32**.
networking.clusterNetwork.hostPrefix	The subnet prefix length to assign to each individual node. For example, if **hostPrefix** is set to **23** then each node is assigned a **/23** subnet out of the given **cidr**. A **hostPrefix** value of **23** provides 510 (2^(32 - 23) - 2) pod IP addresses.	A subnet prefix. The default value is **23**.
networking.serviceNetwork	The IP address block for services. The default value is **172.30.0.0/16**. The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.	An array with an IP address block in CIDR format. For example: `networking:` `  serviceNetwork:` `  - 172.30.0.0/16`
networking.machineNetwork	The IP address blocks for machines. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: `networking:` `  machineNetwork:` `  - cidr: 10.0.0.0/16`

Parameter	Description	Values
networking.machineNetwork.cidr	Required if you use **networking.machineNetwork**. An IP address block. The default value is **10.0.0.0/16** for all platforms other than libvirt. For libvirt, the default value is **192.168.126.0/24**.	An IP network block in CIDR notation. For example, **10.0.0.0/16**.  **NOTE** Set the **networking.machineNetwork** to match the CIDR that the preferred NIC resides in.

5.6.6.1.3. Optional configuration parameters

Optional installation configuration parameters are described in the following table:

Table 5.8. Optional parameters

Parameter	Description	Values
additionalTrustBundle	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String
capabilities	Controls the installation of optional core cluster components. You can reduce the footprint of your OpenShift Container Platform cluster by disabling optional components.	String array
capabilities.baselineCapabilitySet	Selects an initial set of optional capabilities to enable. Valid values are **None**, **v4.11** and **vCurrent**. **v4.11** enables the **baremetal** Operator, the **marketplace** Operator, and the **openshift-samples** content. **vCurrent** installs the recommended set of capabilities for the current version of OpenShift Container Platform. The default value is **vCurrent**.	String

Parameter	Description	Values
capabilities.additionalEnabledCapabilities	Extends the set of optional capabilities beyond what you specify in **baselineCapabilitySet**. Valid values are **baremetal**, **marketplace** and **openshift-samples**. You may specify multiple capabilities in this parameter.	String array
cgroupsV2	Enables Linux control groups version 2 (cgroups v2) on specific nodes in your cluster. The OpenShift Container Platform process for enabling cgroups v2 disables all cgroup version 1 controllers and hierarchies. The OpenShift Container Platform cgroups version 2 feature is in Developer Preview and is not supported by Red Hat at this time.	**true**
compute	The configuration for the machines that comprise the compute nodes.	Array of **MachinePool** objects.
compute.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** and **arm64**. Not all installation options support the 64-bit ARM architecture. To verify if your installation option is supported on your platform, see *Supported installation methods for different platforms* in *Selecting a cluster installation method and preparing it for users*.	String

Parameter	Description	Values
compute.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  **IMPORTANT** If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
compute.name	Required if you use **compute**. The name of the machine pool.	**worker**
compute.platform	Required if you use **compute**. Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the **controlPlane.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
compute.replicas	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to **2**. The default value is **3**.
controlPlane	The configuration for the machines that comprise the control plane.	Array of **MachinePool** objects.

Parameter	Description	Values
controlPlane.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** and **arm64**. Not all installation options support the 64-bit ARM architecture. To verify if your installation option is supported on your platform, see *Supported installation methods for different platforms* in *Selecting a cluster installation method and preparing it for users*.	String
controlPlane.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  IMPORTANT If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
controlPlane.name	Required if you use **controlPlane**. The name of the machine pool.	**master**
controlPlane.platform	Required if you use **controlPlane**. Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the **compute.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
controlPlane.replicas	The number of control plane machines to provision.	The only supported value is **3**, which is the default value.

Parameter	Description	Values
credentialsMode	The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported.  **NOTE** Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the *Cloud Credential Operator* entry in the *Cluster Operators reference* content.  **NOTE** If your AWS account has service control policies (SCP) enabled, you must configure the **credentialsMode** parameter to **Mint**, **Passthrough** or **Manual**.	**Mint**, **Passthrough**, **Manual** or an empty string (**""**).

Parameter	Description	Values
fips	Enable or disable FIPS mode. The default is **false** (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.  **IMPORTANT** To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.  **NOTE** If you are using Azure File storage, you cannot enable FIPS mode.	**false** or **true**

Parameter	Description	Values
imageContentSources	Sources and repositories for the release-image content.	Array of objects. Includes a **source** and, optionally, **mirrors**, as described in the following rows of this table.
imageContentSources.source	Required if you use **imageContentSources**. Specify the repository that users refer to, for example, in image pull specifications.	String
imageContentSources.mirrors	Specify one or more repositories that may also contain the same images.	Array of strings
publish	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	**Internal** or **External**. To deploy a private cluster, which cannot be accessed from the internet, set **publish** to **Internal**. The default value is **External**.
sshKey	The SSH key to authenticate access to your cluster machines.  **NOTE** For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.	For example, **sshKey: ssh-ed25519 AAAA..**.

5.6.6.1.4. Optional AWS configuration parameters

Optional AWS configuration parameters are described in the following table:

Table 5.9. Optional AWS parameters

Parameter	Description	Values
compute.platform.aws.amiID	The AWS AMI used to boot compute machines for the cluster. This is required for regions that require a custom RHCOS AMI.	Any published or custom RHCOS AMI that belongs to the set AWS region. See *RHCOS AMIs for AWS infrastructure* for available AMI IDs.

Parameter	Description	Values
compute.platform.aws.iamRole	A pre-existing AWS IAM role applied to the compute machine pool instance profiles. You can use these fields to match naming schemes and include predefined permissions boundaries for your IAM roles. If undefined, the installation program creates a new IAM role.	The name of a valid AWS IAM role.
compute.platform.aws.rootVolume.iops	The Input/Output Operations Per Second (IOPS) that is reserved for the root volume.	Integer, for example **4000**.
compute.platform.aws.rootVolume.size	The size in GiB of the root volume.	Integer, for example **500**.
compute.platform.aws.rootVolume.type	The type of the root volume.	Valid AWS EBS volume type, such as **io1**.
compute.platform.aws.rootVolume.kmsKeyARN	The Amazon Resource Name (key ARN) of a KMS key. This is required to encrypt OS volumes of worker nodes with a specific KMS key.	Valid key ID or the key ARN
compute.platform.aws.type	The EC2 instance type for the compute machines.	Valid AWS instance type, such as **m4.2xlarge**. See the **Supported AWS machine types** table that follows.
compute.platform.aws.zones	The availability zones where the installation program creates machines for the compute machine pool. If you provide your own VPC, you must provide a subnet in that availability zone.	A list of valid AWS availability zones, such as **us-east-1c**, in a YAML sequence.

Parameter	Description	Values
compute.aws.region	The AWS region that the installation program creates compute resources in.	Any valid AWS region, such as **us-east-1**. You can use the AWS CLI to access the regions available based on your selected instance type. For example: `aws ec2 describe-instance-type-offerings --filters Name=instance-type,Values=c7g.xlarge`  **IMPORTANT** When running on ARM based AWS instances, ensure that you enter a region where AWS Graviton processors are available. See Global availability map in the AWS documentation. Currently, AWS Graviton3 processors are only available in some regions.
controlPlane.platform.aws.amiID	The AWS AMI used to boot control plane machines for the cluster. This is required for regions that require a custom RHCOS AMI.	Any published or custom RHCOS AMI that belongs to the set AWS region. See *RHCOS AMIs for AWS infrastructure* for available AMI IDs.
controlPlane.platform.aws.iamRole	A pre-existing AWS IAM role applied to the control plane machine pool instance profiles. You can use these fields to match naming schemes and include predefined permissions boundaries for your IAM roles. If undefined, the installation program creates a new IAM role.	The name of a valid AWS IAM role.
controlPlane.platform.aws.rootVolume.kmsKeyARN	The Amazon Resource Name (key ARN) of a KMS key. This is required to encrypt OS volumes of control plane nodes with a specific KMS key.	Valid key ID and the key ARN

Parameter	Description	Values
controlPlane.platform.aws.type	The EC2 instance type for the control plane machines.	Valid AWS instance type, such as **m6i.xlarge**. See the **Supported AWS machine types** table that follows.
controlPlane.platform.aws.zones	The availability zones where the installation program creates machines for the control plane machine pool.	A list of valid AWS availability zones, such as **us-east-1c**, in a YAML sequence.
controlPlane.aws.region	The AWS region that the installation program creates control plane resources in.	Valid AWS region, such as **us-east-1**.
platform.aws.amiID	The AWS AMI used to boot all machines for the cluster. If set, the AMI must belong to the same region as the cluster. This is required for regions that require a custom RHCOS AMI.	Any published or custom RHCOS AMI that belongs to the set AWS region. See *RHCOS AMIs for AWS infrastructure* for available AMI IDs.
platform.aws.hostedZone	An existing Route 53 private hosted zone for the cluster. You can only use a pre-existing hosted zone when also supplying your own VPC. The hosted zone must already be associated with the user-provided VPC before installation. Also, the domain of the hosted zone must be the cluster domain or a parent of the cluster domain. If undefined, the installation program creates a new hosted zone.	String, for example **Z3URY6TWQ91KVV**.
platform.aws.serviceEndpoints.name	The AWS service endpoint name. Custom endpoints are only required for cases where alternative AWS endpoints, like FIPS, must be used. Custom API endpoints can be specified for EC2, S3, IAM, Elastic Load Balancing, Tagging, Route 53, and STS AWS services.	Valid AWS service endpoint name.

Parameter	Description	Values
platform.aws.serviceEndpoints.url	The AWS service endpoint URL. The URL must use the **https** protocol and the host must trust the certificate.	Valid AWS service endpoint URL.
platform.aws.userTags	A map of keys and values that the installation program adds as tags to all resources that it creates.	Any valid YAML map, such as key value pairs in the **<key>: <value>** format. For more information about AWS tags, see Tagging Your Amazon EC2 Resources in the AWS documentation.
platform.aws.subnets	If you provide the VPC instead of allowing the installation program to create the VPC for you, specify the subnet for the cluster to use. The subnet must be part of the same **machineNetwork[].cidr** ranges that you specify. For a standard cluster, specify a public and a private subnet for each availability zone. For a private cluster, specify a private subnet for each availability zone.	Valid subnet IDs.

5.6.6.2. Minimum resource requirements for cluster installation

Each cluster machine must meet the following minimum requirements:

Table 5.10. Minimum resource requirements

Machine	Operating System	vCPU [1]	Virtual RAM	Storage	IOPS [2]
Bootstrap	RHCOS	4	16 GB	100 GB	300
Control plane	RHCOS	4	16 GB	100 GB	300
Compute	RHCOS, RHEL 8.6 and later [3]	2	8 GB	100 GB	300

1. One vCPU is equivalent to one physical core when simultaneous multithreading (SMT), or hyperthreading, is not enabled. When enabled, use the following formula to calculate the corresponding ratio: (threads per core × cores) × sockets = vCPUs.

2. OpenShift Container Platform and Kubernetes are sensitive to disk performance, and faster storage is recommended, particularly for etcd on the control plane nodes which require a 10 ms

p99 fsync duration. Note that on many cloud platforms, storage size and IOPS scale together, so you might need to over-allocate storage volume to obtain sufficient performance.

3. As with all user-provisioned installations, if you choose to use RHEL compute machines in your cluster, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks. Use of RHEL 7 compute machines is deprecated and has been removed in OpenShift Container Platform 4.10 and later.

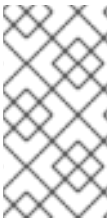
If an instance type for your platform meets the minimum requirements for cluster machines, it is supported to use in OpenShift Container Platform.

Additional resources

- Optimizing storage

5.6.6.3. Tested instance types for AWS

The following Amazon Web Services (AWS) instance types have been tested with OpenShift Container Platform.



NOTE

Use the machine types included in the following charts for your AWS instances. If you use an instance type that is not listed in the chart, ensure that the instance size you use matches the minimum resource requirements that are listed in "Minimum resource requirements for cluster installation".

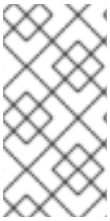
Example 5.18. Machine types based on 64-bit x86 architecture

- **c4.***
- **c5.***
- **c5a.***
- **i3.***
- **m4.***
- **m5.***
- **m5a.***
- **m6a.***
- **m6i.***
- **r4.***
- **r5.***
- **r5a.***
- **r6i.***

- **t3.***
- **t3a.***

5.6.6.4. Tested instance types for AWS on 64-bit ARM infrastructures

The following Amazon Web Services (AWS) ARM64 instance types have been tested with OpenShift Container Platform.



NOTE

Use the machine types included in the following charts for your AWS ARM instances. If you use an instance type that is not listed in the chart, ensure that the instance size you use matches the minimum resource requirements that are listed in "Minimum resource requirements for cluster installation".

Example 5.19. Machine types based on 64-bit ARM architecture

- **c6g.***
- **m6g.***

5.6.6.5. Sample customized install-config.yaml file for AWS

You can customize the installation configuration file (**install-config.yaml**) to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.

IMPORTANT

This sample YAML file is provided for reference only. You must obtain your **install-config.yaml** file by using the installation program and modify it.

```
apiVersion: v1
baseDomain: example.com 1
credentialsMode: Mint 2
controlPlane: 3 4
  hyperthreading: Enabled 5
  name: master
  platform:
    aws:
      zones:
      - us-west-2a
      - us-west-2b
      rootVolume:
        iops: 4000
        size: 500
        type: io1 6
      metadataService:
        authentication: Optional 7
      type: m6i.xlarge
```

```
  replicas: 3
compute: 8
- hyperthreading: Enabled 9
  name: worker
  platform:
    aws:
      rootVolume:
        iops: 2000
        size: 500
        type: io1 10
      metadataService:
        authentication: Optional 11
      type: c5.4xlarge
      zones:
      - us-west-2c
  replicas: 3
metadata:
  name: test-cluster 12
networking: 13
  clusterNetwork:
  - cidr: 10.128.0.0/14
    hostPrefix: 23
  machineNetwork:
  - cidr: 10.0.0.0/16
  networkType: OpenShiftSDN
  serviceNetwork:
  - 172.30.0.0/16
platform:
  aws:
    region: us-west-2 14
    userTags:
      adminContact: jdoe
      costCenter: 7536
    amiID: ami-96c6f8f7 15
    serviceEndpoints: 16
      - name: ec2
        url: https://vpce-id.ec2.us-west-2.vpce.amazonaws.com
fips: false 17
sshKey: ssh-ed25519 AAAA... 18
pullSecret: '{"auths": ...}' 19
```

1 12 14 19 Required. The installation program prompts you for this value.

2 Optional: Add this parameter to force the Cloud Credential Operator (CCO) to use the specified mode, instead of having the CCO dynamically try to determine the capabilities of the credentials. For details about CCO modes, see the *Cloud Credential Operator* entry in the *Red Hat Operators reference* content.

3 8 13 If you do not provide these parameters and values, the installation program provides the default value.

4 The **controlPlane** section is a single mapping, but the **compute** section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, **-**, and the first line of the **controlPlane** section must not. Only one control plane pool is used.

5 9 Whether to enable or disable simultaneous multithreading, or **hyperthreading**. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores. You

IMPORTANT

If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance. Use larger instance types, such as **m4.2xlarge** or **m5.2xlarge**, for your machines if you disable simultaneous multithreading.

6 10 To configure faster storage for etcd, especially for larger clusters, set the storage type as **io1** and set **iops** to **2000**.

7 11 Whether to require the Amazon EC2 Instance Metadata Service v2 (IMDSv2). To require IMDSv2, set the parameter value to **Required**. To allow the use of both IMDSv1 and IMDSv2, set the parameter value to **Optional**. If no value is specified, both IMDSv1 and IMDSv2 are allowed.

NOTE

The IMDS configuration for control plane machines that is set during cluster installation can only be changed by using the AWS CLI. The IMDS configuration for compute machines can be changed by using machine sets.

15 The ID of the AMI used to boot machines for the cluster. If set, the AMI must belong to the same region as the cluster.

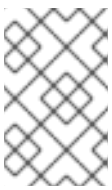
16 The AWS service endpoints. Custom endpoints are required when installing to an unknown AWS region. The endpoint URL must use the **https** protocol and the host must trust the certificate.

17 Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.

IMPORTANT

To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.

18 You can optionally provide the **sshKey** value that you use to access the machines in your cluster.



NOTE

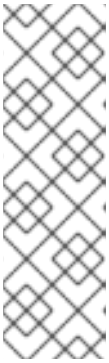
For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

5.6.6.6. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.



NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: ec2.<region>.amazonaws.com,elasticloadbalancing.
<region>.amazonaws.com,s3.<region>.amazonaws.com 3
additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
```

1. A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
2. A proxy URL to use for creating HTTPS connections outside the cluster.
3. A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use ***** to bypass the proxy for all destinations. If you have added the Amazon **EC2**,**Elastic Load Balancing**, and **S3** VPC endpoints to your VPC, you must add these endpoints to the **noProxy** field.
4. If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace that contains one or more additional CA certificates that are required for proxying HTTPS connections. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges these contents with the Red Hat

Enterprise Linux CoreOS (RHCOS) trust bundle, and this config map is referenced in the **trustedCA** field of the **Proxy** object. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.

NOTE

The installation program does not support the proxy **readinessEndpoints** field.

NOTE

If the installer times out, restart and then complete the deployment by using the **wait-for** command of the installer. For example:

```
$ ./openshift-install wait-for install-complete --log-level debug
```

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.

NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

5.6.7. Cluster Network Operator configuration

The configuration for the cluster network is specified as part of the Cluster Network Operator (CNO) configuration and stored in a custom resource (CR) object that is named **cluster**. The CR specifies the fields for the **Network** API in the **operator.openshift.io** API group.

The CNO configuration inherits the following fields during cluster installation from the **Network** API in the **Network.config.openshift.io** API group and these fields cannot be changed:

clusterNetwork
IP address pools from which pod IP addresses are allocated.

serviceNetwork
IP address pool for services.

defaultNetwork.type
Cluster network provider, such as OpenShift SDN or OVN-Kubernetes.

You can specify the cluster network provider configuration for your cluster by setting the fields for the **defaultNetwork** object in the CNO object named **cluster**.

5.6.7.1. Cluster Network Operator configuration object

The fields for the Cluster Network Operator (CNO) are described in the following table:

Table 5.11. Cluster Network Operator configuration object

Field	Type	Description
metadata.name	**string**	The name of the CNO object. This name is always **cluster**.
spec.clusterNetwork	**array**	A list specifying the blocks of IP addresses from which pod IP addresses are allocated and the subnet prefix length assigned to each individual node in the cluster. For example: `spec:` `  clusterNetwork:` `  - cidr: 10.128.0.0/19` `  hostPrefix: 23` `  - cidr: 10.128.32.0/19` `  hostPrefix: 23` You can customize this field only in the **install-config.yaml** file before you create the manifests. The value is read-only in the manifest file.
spec.serviceNetwork	**array**	A block of IP addresses for services. The OpenShift SDN and OVN-Kubernetes Container Network Interface (CNI) network providers support only a single IP address block for the service network. For example: `spec:` `  serviceNetwork:` `  - 172.30.0.0/14` You can customize this field only in the **install-config.yaml** file before you create the manifests. The value is read-only in the manifest file.
spec.defaultNetwork	**object**	Configures the Container Network Interface (CNI) cluster network provider for the cluster network.
spec.kubeProxyConfig	**object**	The fields for this object specify the kube-proxy configuration. If you are using the OVN-Kubernetes cluster network provider, the kube-proxy configuration has no effect.

defaultNetwork object configuration

The values for the **defaultNetwork** object are defined in the following table:

Table 5.12. **defaultNetwork** object

Field	Type	Description

Field	Type	Description
type	**string**	Either **OpenShiftSDN** or **OVNKubernetes**. The cluster network provider is selected during installation. This value cannot be changed after cluster installation.  **NOTE** OpenShift Container Platform uses the OpenShift SDN Container Network Interface (CNI) cluster network provider by default.
openshiftSDNConfig	**object**	This object is only valid for the OpenShift SDN cluster network provider.
ovnKubernetesConfig	**object**	This object is only valid for the OVN-Kubernetes cluster network provider.

Configuration for the OpenShift SDN CNI cluster network provider
The following table describes the configuration fields for the OpenShift SDN Container Network Interface (CNI) cluster network provider.

Table 5.13. **openshiftSDNConfig** object

Field	Type	Description
mode	**string**	Configures the network isolation mode for OpenShift SDN. The default value is **NetworkPolicy**. The values **Multitenant** and **Subnet** are available for backwards compatibility with OpenShift Container Platform 3.x but are not recommended. This value cannot be changed after cluster installation.

Field	Type	Description
mtu	**integer**	The maximum transmission unit (MTU) for the VXLAN overlay network. This is detected automatically based on the MTU of the primary network interface. You do not normally need to override the detected MTU. If the auto-detected value is not what you expect it to be, confirm that the MTU on the primary network interface on your nodes is correct. You cannot use this option to change the MTU value of the primary network interface on the nodes. If your cluster requires different MTU values for different nodes, you must set this value to **50** less than the lowest MTU value in your cluster. For example, if some nodes in your cluster have an MTU of **9001**, and some have an MTU of**1500**, you must set this value to **1450**. This value cannot be changed after cluster installation.
vxlanPort	**integer**	The port to use for all VXLAN packets. The default value is **4789**. This value cannot be changed after cluster installation. If you are running in a virtualized environment with existing nodes that are part of another VXLAN network, then you might be required to change this. For example, when running an OpenShift SDN overlay on top of VMware NSX-T, you must select an alternate port for the VXLAN, because both SDNs use the same default VXLAN port number. On Amazon Web Services (AWS), you can select an alternate port for the VXLAN between port **9000** and port **9999**.

Example OpenShift SDN configuration

```
defaultNetwork:
  type: OpenShiftSDN
  openshiftSDNConfig:
    mode: NetworkPolicy
    mtu: 1450
    vxlanPort: 4789
```

Configuration for the OVN-Kubernetes CNI cluster network provider

The following table describes the configuration fields for the OVN-Kubernetes CNI cluster network provider.

Table 5.14. ovnKubernetesConfig object

Field	Type	Description

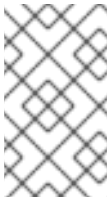
Field	Type	Description
mtu	**integer**	The maximum transmission unit (MTU) for the Geneve (Generic Network Virtualization Encapsulation) overlay network. This is detected automatically based on the MTU of the primary network interface. You do not normally need to override the detected MTU. If the auto-detected value is not what you expect it to be, confirm that the MTU on the primary network interface on your nodes is correct. You cannot use this option to change the MTU value of the primary network interface on the nodes. If your cluster requires different MTU values for different nodes, you must set this value to **100** less than the lowest MTU value in your cluster. For example, if some nodes in your cluster have an MTU of **9001**, and some have an MTU of**1500**, you must set this value to **1400**.
genevePort	**integer**	The port to use for all Geneve packets. The default value is **6081**. This value cannot be changed after cluster installation.
ipsecConfig	**object**	Specify an empty object to enable IPsec encryption.
policyAuditConfig	**object**	Specify a configuration object for customizing network policy audit logging. If unset, the defaults audit log settings are used.
gatewayConfig	**object**	Optional: Specify a configuration object for customizing how egress traffic is sent to the node gateway.  NOTE While migrating egress traffic, you can expect some disruption to workloads and service traffic until the Cluster Network Operator (CNO) successfully rolls out the changes.

Table 5.15. **policyAuditConfig** object

Field	Type	Description
rateLimit	integer	The maximum number of messages to generate every second per node. The default value is **20** messages per second.
maxFileSize	integer	The maximum size for the audit log in bytes. The default value is **50000000** or 50 MB.

Field	Type	Description
destination	string	One of the following additional audit log targets: **libc** The libc **syslog()** function of the journald process on the host. **udp:<host>:<port>** A syslog server. Replace **<host>:<port>** with the host and port of the syslog server. **unix:<file>** A Unix Domain Socket file specified by **<file>**. **null** Do not send the audit logs to any additional target.
syslogFacility	string	The syslog facility, such as **kern**, as defined by RFC5424. The default value is **local0**.

Table 5.16. **gatewayConfig** object

Field	Type	Description
routingViaHost	**boolean**	Set this field to **true** to send egress traffic from pods to the host networking stack. For highly-specialized installations and applications that rely on manually configured routes in the kernel routing table, you might want to route egress traffic to the host networking stack. By default, egress traffic is processed in OVN to exit the cluster and is not affected by specialized routes in the kernel routing table. The default value is **false**. This field has an interaction with the Open vSwitch hardware offloading feature. If you set this field to **true**, you do not receive the performance benefits of the offloading because egress traffic is processed by the host networking stack.

Example OVN-Kubernetes configuration with IPSec enabled

```
defaultNetwork:
  type: OVNKubernetes
  ovnKubernetesConfig:
    mtu: 1400
    genevePort: 6081
    ipsecConfig: {}
```

kubeProxyConfig object configuration

The values for the **kubeProxyConfig** object are defined in the following table:

Table 5.17. **kubeProxyConfig** object

Field	Type	Description
iptablesSyncPeriod	**string**	The refresh period for **iptables** rules. The default value is **30s**. Valid suffixes include **s**, **m**, and **h** and are described in the Go **time** package documentation. NOTE Because of performance improvements introduced in OpenShift Container Platform 4.3 and greater, adjusting the **iptablesSyncPeriod** parameter is no longer necessary.
proxyArguments.iptables-min-sync-period	**array**	The minimum duration before refreshing **iptables** rules. This field ensures that the refresh does not happen too frequently. Valid suffixes include **s**, **m**, and **h** and are described in the Go **time** package. The default value is: `kubeProxyConfig:` `  proxyArguments:` `  iptables-min-sync-period:` `  - 0s`

5.6.8. Specifying advanced network configuration

You can use advanced network configuration for your cluster network provider to integrate your cluster into your existing network environment. You can specify advanced network configuration only before you install the cluster.

IMPORTANT

Customizing your network configuration by modifying the OpenShift Container Platform manifest files created by the installation program is not supported. Applying a manifest file that you create, as in the following procedure, is supported.

Prerequisites

- You have created the **install-config.yaml** file and completed any modifications to it.

Procedure

1. Change to the directory that contains the installation program and create the manifests:

```
$ ./openshift-install create manifests --dir <installation_directory> 1
```

1 **<installation_directory>** specifies the name of the directory that contains the **install-config.yaml** file for your cluster.

2. Create a stub manifest file for the advanced network configuration that is named **cluster-network-03-config.yml** in the **<installation_directory>/manifests/** directory:

```
apiVersion: operator.openshift.io/v1
kind: Network
metadata:
  name: cluster
spec:
```

3. Specify the advanced network configuration for your cluster in the **cluster-network-03-config.yml** file, such as in the following examples:

Specify a different VXLAN port for the OpenShift SDN network provider

```
apiVersion: operator.openshift.io/v1
kind: Network
metadata:
  name: cluster
spec:
  defaultNetwork:
    openshiftSDNConfig:
      vxlanPort: 4800
```

Enable IPsec for the OVN-Kubernetes network provider

```
apiVersion: operator.openshift.io/v1
kind: Network
metadata:
  name: cluster
spec:
  defaultNetwork:
    ovnKubernetesConfig:
      ipsecConfig: {}
```

4. Optional: Back up the **manifests/cluster-network-03-config.yml** file. The installation program consumes the **manifests/** directory when you create the Ignition config files.

NOTE

For more information on using a Network Load Balancer (NLB) on AWS, see Configuring Ingress cluster traffic on AWS using a Network Load Balancer.

5.6.9. Configuring an Ingress Controller Network Load Balancer on a new AWS cluster

You can create an Ingress Controller backed by an AWS Network Load Balancer (NLB) on a new cluster.

Prerequisites

- Create the **install-config.yaml** file and complete any modifications to it.

Procedure

Create an Ingress Controller backed by an AWS NLB on a new cluster.

1. Change to the directory that contains the installation program and create the manifests:

```
$ ./openshift-install create manifests --dir <installation_directory> 1
```

1 For **<installation_directory>**, specify the name of the directory that contains the **install-config.yaml** file for your cluster.

2. Create a file that is named **cluster-ingress-default-ingresscontroller.yaml** in the **<installation_directory>/manifests/** directory:

```
$ touch <installation_directory>/manifests/cluster-ingress-default-ingresscontroller.yaml 1
```

1 For **<installation_directory>**, specify the directory name that contains the **manifests/** directory for your cluster.

After creating the file, several network configuration files are in the **manifests/** directory, as shown:

```
$ ls <installation_directory>/manifests/cluster-ingress-default-ingresscontroller.yaml
```

Example output

```
cluster-ingress-default-ingresscontroller.yaml
```

3. Open the **cluster-ingress-default-ingresscontroller.yaml** file in an editor and enter a custom resource (CR) that describes the Operator configuration you want:

```
apiVersion: operator.openshift.io/v1
kind: IngressController
metadata:
  creationTimestamp: null
  name: default
  namespace: openshift-ingress-operator
spec:
  endpointPublishingStrategy:
    loadBalancer:
      scope: External
      providerParameters:
        type: AWS
        aws:
          type: NLB
    type: LoadBalancerService
```

4. Save the **cluster-ingress-default-ingresscontroller.yaml** file and quit the text editor.

5. Optional: Back up the **manifests/cluster-ingress-default-ingresscontroller.yaml** file. The installation program deletes the **manifests/** directory when creating the cluster.

5.6.10. Configuring hybrid networking with OVN-Kubernetes

You can configure your cluster to use hybrid networking with OVN-Kubernetes. This allows a hybrid cluster that supports different node networking configurations. For example, this is necessary to run both Linux and Windows nodes in a cluster.

IMPORTANT

You must configure hybrid networking with OVN-Kubernetes during the installation of your cluster. You cannot switch to hybrid networking after the installation process.

Prerequisites

- You defined **OVNKubernetes** for the **networking.networkType** parameter in the **install-config.yaml** file. See the installation documentation for configuring OpenShift Container Platform network customizations on your chosen cloud provider for more information.

Procedure

1. Change to the directory that contains the installation program and create the manifests:

```
$ ./openshift-install create manifests --dir <installation_directory>
```

   where:

   <installation_directory>

   Specifies the name of the directory that contains the **install-config.yaml** file for your cluster.

2. Create a stub manifest file for the advanced network configuration that is named **cluster-network-03-config.yml** in the **<installation_directory>/manifests/** directory:

```
$ cat <<EOF > <installation_directory>/manifests/cluster-network-03-config.yml
apiVersion: operator.openshift.io/v1
kind: Network
metadata:
  name: cluster
spec:
EOF
```

   where:

   <installation_directory>

   Specifies the directory name that contains the **manifests/** directory for your cluster.

3. Open the **cluster-network-03-config.yml** file in an editor and configure OVN-Kubernetes with hybrid networking, such as in the following example:

   Specify a hybrid networking configuration

```
apiVersion: operator.openshift.io/v1
kind: Network
metadata:
  name: cluster
spec:
  defaultNetwork:
```

```
ovnKubernetesConfig:
  hybridOverlayConfig:
    hybridClusterNetwork: 1
    - cidr: 10.132.0.0/14
      hostPrefix: 23
    hybridOverlayVXLANPort: 9898 2
```

1 Specify the CIDR configuration used for nodes on the additional overlay network. The **hybridClusterNetwork** CIDR cannot overlap with the **clusterNetwork** CIDR.

2 Specify a custom VXLAN port for the additional overlay network. This is required for running Windows nodes in a cluster installed on vSphere, and must not be configured for any other cloud provider. The custom port can be any open port excluding the default **4789** port. For more information on this requirement, see the Microsoft documentation on Pod-to-pod connectivity between hosts is broken.

NOTE

Windows Server Long-Term Servicing Channel (LTSC): Windows Server 2019 is not supported on clusters with a custom **hybridOverlayVXLANPort** value because this Windows server version does not support selecting a custom VXLAN port.

4. Save the **cluster-network-03-config.yml** file and quit the text editor.
5. Optional: Back up the **manifests/cluster-network-03-config.yml** file. The installation program deletes the **manifests/** directory when creating the cluster.

NOTE

For more information on using Linux and Windows nodes in the same cluster, see Understanding Windows container workloads.

5.6.11. Deploying the cluster

You can install OpenShift Container Platform on a compatible cloud platform.

IMPORTANT

You can run the **create cluster** command of the installation program only once, during initial installation.

Prerequisites

- Configure an account with the cloud platform that hosts your cluster.
- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.

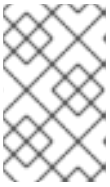
Procedure

1. Change to the directory that contains the installation program and initialize the cluster deployment:

```
$ ./openshift-install create cluster --dir <installation_directory> \ 1
    --log-level=info 2
```

1 For **<installation_directory>**, specify the location of your customized **./install-config.yaml** file.

2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.



NOTE

If the cloud provider account that you configured on your host does not have sufficient permissions to deploy the cluster, the installation process stops, and the missing permissions are displayed.

2. Optional: Remove or disable the **AdministratorAccess** policy from the IAM account that you used to install the cluster.

NOTE

The elevated permissions provided by the **AdministratorAccess** policy are required only during installation.

Verification

When the cluster deployment completes successfully:

- The terminal displays directions for accessing your cluster, including a link to the web console and credentials for the **kubeadmin** user.
- Credential information also outputs to **<installation_directory>/.openshift_install.log**.

IMPORTANT

Do not delete the installation program or the files that the installation program creates. Both are required to delete the cluster.

Example output

```
...
INFO Install complete!
INFO To access the cluster as the system:admin user when using 'oc', run 'export
KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
INFO Access the OpenShift web-console here: https://console-openshift-
console.apps.mycluster.example.com
INFO Login to the console with user: "kubeadmin", and password: "password"
INFO Time elapsed: 36m22s
```

IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

5.6.12. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.

IMPORTANT

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.11. Download and install the new version of **oc**.

Installing the OpenShift CLI on Linux

You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the architecture in the **Product Variant** drop-down menu.
3. Select the appropriate version in the **Version** drop-down menu.
4. Click **Download Now** next to the **OpenShift v4.11 Linux Client** entry and save the file.
5. Unpack the archive:

```
$ tar xvf <file>
```

6. Place the **oc** binary in a directory that is on your **PATH**.
   To check your **PATH**, execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.
   To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
C:\> oc <command>
```

Installing the OpenShift CLI on macOS

You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 macOS Client** entry and save the file.

NOTE

For macOS arm64, choose the **OpenShift v4.11 macOS arm64 Client** entry.

4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your PATH.
   To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

5.6.13. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

Example output

```
system:admin
```

5.6.14. Logging in to the cluster by using the web console

The **kubeadmin** user exists by default after an OpenShift Container Platform installation. You can log in to your cluster as the **kubeadmin** user by using the OpenShift Container Platform web console.

Prerequisites

- You have access to the installation host.
- You completed a cluster installation and all cluster Operators are available.

Procedure

1. Obtain the password for the **kubeadmin** user from the **kubeadmin-password** file on the installation host:

```
$ cat <installation_directory>/auth/kubeadmin-password
```

NOTE

Alternatively, you can obtain the **kubeadmin** password from the **<installation_directory>/.openshift_install.log** log file on the installation host.

2. List the OpenShift Container Platform web console route:

```
$ oc get routes -n openshift-console | grep 'console-openshift'
```

NOTE

Alternatively, you can obtain the OpenShift Container Platform route from the **<installation_directory>/.openshift_install.log** log file on the installation host.

Example output

```
console     console-openshift-console.apps.<cluster_name>.<base_domain>           console
https   reencrypt/Redirect   None
```

3. Navigate to the route detailed in the output of the preceding command in a web browser and log in as the **kubeadmin** user.

Additional resources

- See Accessing the web console for more details about accessing and understanding the OpenShift Container Platform web console.

5.6.15. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.11, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to OpenShift Cluster Manager Hybrid Cloud Console.

After you confirm that your OpenShift Cluster Manager Hybrid Cloud Console inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, use subscription watch to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

Additional resources

- See About remote health monitoring for more information about the Telemetry service.

5.6.16. Next steps

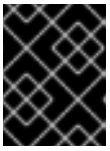
- Validating an installation.
- Customize your cluster.
- If necessary, you can opt out of remote health reporting .
- If necessary, you can remove cloud provider credentials.

5.7. INSTALLING A CLUSTER ON AWS IN A RESTRICTED NETWORK

In OpenShift Container Platform version 4.11, you can install a cluster on Amazon Web Services (AWS) in a restricted network by creating an internal mirror of the installation release content on an existing Amazon Virtual Private Cloud (VPC).

5.7.1. Prerequisites

- You reviewed details about the OpenShift Container Platform installation and update processes.
- You read the documentation on selecting a cluster installation method and preparing it for users.
- You mirrored the images for a disconnected installation to your registry and obtained the **imageContentSources** data for your version of OpenShift Container Platform.



IMPORTANT

Because the installation media is on the mirror host, you can use that computer to complete all installation steps.

- You have an existing VPC in AWS. When installing to a restricted network using installer-provisioned infrastructure, you cannot use the installer-provisioned VPC. You must use a user-provisioned VPC that satisfies one of the following requirements:
  - Contains the mirror registry
  - Has firewall rules or a peering connection to access the mirror registry hosted elsewhere
- You configured an AWS account to host the cluster.

IMPORTANT

If you have an AWS profile stored on your computer, it must not use a temporary session token that you generated while using a multi-factor authentication device. The cluster continues to use your current AWS credentials to create AWS resources for the entire life of the cluster, so you must use key-based, long-lived credentials. To generate appropriate keys, see Managing Access Keys for IAM Users in the AWS documentation. You can supply the keys when you run the installation program.

- You downloaded the AWS CLI and installed it on your computer. See Install the AWS CLI Using the Bundled Installer (Linux, macOS, or Unix) in the AWS documentation.
- If you use a firewall and plan to use the Telemetry service, you configured the firewall to allow the sites that your cluster requires access to.

NOTE

If you are configuring a proxy, be sure to also review this site list.

- If the cloud identity and access management (IAM) APIs are not accessible in your environment, or if you do not want to store an administrator-level credential secret in the **kube-system** namespace, you can manually create and maintain IAM credentials.

5.7.2. About installations in restricted networks

In OpenShift Container Platform 4.11, you can perform an installation that does not require an active connection to the internet to obtain software components. Restricted network installations can be completed using installer-provisioned infrastructure or user-provisioned infrastructure, depending on the cloud platform to which you are installing the cluster.

If you choose to perform a restricted network installation on a cloud platform, you still require access to its cloud APIs. Some cloud functions, like Amazon Web Service's Route 53 DNS and IAM services, require internet access. Depending on your network, you might require less internet access for an installation on bare metal hardware or on VMware vSphere.

To complete a restricted network installation, you must create a registry that mirrors the contents of the OpenShift image registry and contains the installation media. You can create this registry on a mirror host, which can access both the internet and your closed network, or by using other methods that meet your restrictions.

5.7.2.1. Additional limits

Clusters in restricted networks have the following additional limitations and restrictions:

- The **ClusterVersion** status includes an **Unable to retrieve available updates** error.
- By default, you cannot use the contents of the Developer Catalog because you cannot access the required image stream tags.

5.7.3. About using a custom VPC

In OpenShift Container Platform 4.11, you can deploy a cluster into existing subnets in an existing Amazon Virtual Private Cloud (VPC) in Amazon Web Services (AWS). By deploying OpenShift Container Platform into an existing AWS VPC, you might be able to avoid limit constraints in new accounts or more easily abide by the operational constraints that your company's guidelines set. If you cannot obtain the infrastructure creation permissions that are required to create the VPC yourself, use this installation option.

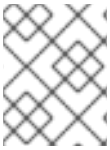
Because the installation program cannot know what other components are also in your existing subnets, it cannot choose subnet CIDRs and so forth on your behalf. You must configure networking for the subnets that you install your cluster to yourself.

5.7.3.1. Requirements for using your VPC

The installation program no longer creates the following components:

- Internet gateways
- NAT gateways
- Subnets
- Route tables
- VPCs

- VPC DHCP options
- VPC endpoints



NOTE

The installation program requires that you use the cloud-provided DNS server. Using a custom DNS server is not supported and causes the installation to fail.

If you use a custom VPC, you must correctly configure it and its subnets for the installation program and the cluster to use. See Amazon VPC console wizard configurations and Work with VPCs and subnets in the AWS documentation for more information on creating and managing an AWS VPC.

The installation program cannot:

- Subdivide network ranges for the cluster to use.
- Set route tables for the subnets.
- Set VPC options like DHCP.

You must complete these tasks before you install the cluster. See VPC networking components and Route tables for your VPC for more information on configuring networking in an AWS VPC.

Your VPC must meet the following characteristics:

- The VPC must not use the **kubernetes.io/cluster/.*: owned**, **Name**, and **openshift.io/cluster** tags.
  The installation program modifies your subnets to add the **kubernetes.io/cluster/.*: shared** tag, so your subnets must have at least one free tag slot available for it. See Tag Restrictions in the AWS documentation to confirm that the installation program can add a tag to each subnet that you specify. You cannot use a **Name** tag, because it overlaps with the EC2 **Name** field and the installation fails.
- You must enable the **enableDnsSupport** and **enableDnsHostnames** attributes in your VPC, so that the cluster can use the Route 53 zones that are attached to the VPC to resolve cluster's internal DNS records. See DNS Support in Your VPC in the AWS documentation.
  If you prefer to use your own Route 53 hosted private zone, you must associate the existing hosted zone with your VPC prior to installing a cluster. You can define your hosted zone using the **platform.aws.hostedZone** field in the **install-config.yaml** file.

If you are working in a disconnected environment, you are unable to reach the public IP addresses for EC2, ELB, and S3 endpoints. Depending on the level to which you want to restrict internet traffic during the installation, the following configuration options are available:

Option 1: Create VPC endpoints
Create a VPC endpoint and attach it to the subnets that the clusters are using. Name the endpoints as follows:

- **ec2.<region>.amazonaws.com**
- **elasticloadbalancing.<region>.amazonaws.com**
- **s3.<region>.amazonaws.com**

With this option, network traffic remains private between your VPC and the required AWS services.

Option 2: Create a proxy without VPC endpoints
As part of the installation process, you can configure an HTTP or HTTPS proxy. With this option, internet traffic goes through the proxy to reach the required AWS services.

Option 3: Create a proxy with VPC endpoints
As part of the installation process, you can configure an HTTP or HTTPS proxy with VPC endpoints. Create a VPC endpoint and attach it to the subnets that the clusters are using. Name the endpoints as follows:

- **ec2.<region>.amazonaws.com**
- **elasticloadbalancing.<region>.amazonaws.com**
- **s3.<region>.amazonaws.com**

When configuring the proxy in the **install-config.yaml** file, add these endpoints to the **noProxy** field. With this option, the proxy prevents the cluster from accessing the internet directly. However, network traffic remains private between your VPC and the required AWS services.

Required VPC components

You must provide a suitable VPC and subnets that allow communication to your machines.

Component	AWS type	Description
VPC	• **AWS::EC2::VPC** • **AWS::EC2::VPCEndpoint**	You must provide a public VPC for the cluster to use. The VPC uses an endpoint that references the route tables for each subnet to improve communication with the registry that is hosted in S3.
Public subnets	• **AWS::EC2::Subnet** • **AWS::EC2::SubnetNetworkAclAssociation**	Your VPC must have public subnets for between 1 and 3 availability zones and associate them with appropriate Ingress rules.
Internet gateway	• **AWS::EC2::InternetGateway** • **AWS::EC2::VPCGatewayAttachment** • **AWS::EC2::RouteTable** • **AWS::EC2::Route** • **AWS::EC2::SubnetRouteTableAssociation** • **AWS::EC2::NatGateway** • **AWS::EC2::EIP**	You must have a public internet gateway, with public routes, attached to the VPC. In the provided templates, each public subnet has a NAT gateway with an EIP address. These NAT gateways allow cluster resources, like private subnet instances, to reach the internet and are not required for some restricted network or proxy scenarios.

<table>
<tr><th>Component</th><th>AWS type</th><th colspan="2">Description</th></tr>
<tr><td rowspan="7">Network access control</td><td rowspan="7">AWS::EC2::NetworkAcl
AWS::EC2::NetworkAclEntry</td><td colspan="2">You must allow the VPC to access the following ports:</td></tr>
<tr><td>Port</td><td>Reason</td></tr>
<tr><td>80</td><td>Inbound HTTP traffic</td></tr>
<tr><td>443</td><td>Inbound HTTPS traffic</td></tr>
<tr><td>22</td><td>Inbound SSH traffic</td></tr>
<tr><td>1024 - 65535</td><td>Inbound ephemeral traffic</td></tr>
<tr><td>0 - 65535</td><td>Outbound ephemeral traffic</td></tr>
<tr><td>Private subnets</td><td>AWS::EC2::Subnet
AWS::EC2::RouteTable
AWS::EC2::SubnetRouteTableAssociation</td><td colspan="2">Your VPC can have private subnets. The provided CloudFormation templates can create private subnets for between 1 and 3 availability zones. If you use private subnets, you must provide appropriate routes and tables for them.</td></tr>
</table>

5.7.3.2. VPC validation

To ensure that the subnets that you provide are suitable, the installation program confirms the following data:

- All the subnets that you specify exist.
- You provide private subnets.
- The subnet CIDRs belong to the machine CIDR that you specified.
- You provide subnets for each availability zone. Each availability zone contains no more than one public and one private subnet. If you use a private cluster, provide only a private subnet for each availability zone. Otherwise, provide exactly one public and private subnet for each availability zone.
- You provide a public subnet for each private subnet availability zone. Machines are not provisioned in availability zones that you do not provide private subnets for.

If you destroy a cluster that uses an existing VPC, the VPC is not deleted. When you remove the OpenShift Container Platform cluster from a VPC, the **kubernetes.io/cluster/.*: shared** tag is removed from the subnets that it used.

5.7.3.3. Division of permissions

Starting with OpenShift Container Platform 4.3, you do not need all of the permissions that are required for an installation program-provisioned infrastructure cluster to deploy a cluster. This change mimics the division of permissions that you might have at your company: some individuals can create different resource in your clouds than others. For example, you might be able to create application-specific items, like instances, buckets, and load balancers, but not networking-related components such as VPCs, subnets, or ingress rules.

The AWS credentials that you use when you create your cluster do not need the networking permissions that are required to make VPCs and core networking components within the VPC, such as subnets, routing tables, internet gateways, NAT, and VPN. You still need permission to make the application resources that the machines within the cluster require, such as ELBs, security groups, S3 buckets, and nodes.

5.7.3.4. Isolation between clusters

If you deploy OpenShift Container Platform to an existing network, the isolation of cluster services is reduced in the following ways:

- You can install multiple OpenShift Container Platform clusters in the same VPC.
- ICMP ingress is allowed from the entire network.
- TCP 22 ingress (SSH) is allowed to the entire network.
- Control plane TCP 6443 ingress (Kubernetes API) is allowed to the entire network.
- Control plane TCP 22623 ingress (MCS) is allowed to the entire network.

5.7.4. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.11, you require access to the internet to obtain the images that are necessary to install your cluster.

You must have internet access to:

- Access OpenShift Cluster Manager Hybrid Cloud Console to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access Quay.io to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.

IMPORTANT

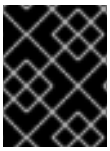
If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

5.7.5. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the **~/.ssh/authorized_keys** list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The **./openshift-install gather** command also requires the SSH public key to be in place on the cluster nodes.



IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.

NOTE

You must use a local key, not one that you configured with platform-specific approaches such as AWS key pairs.

Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N '' -f <path>/<file_name>
```
(1)

(1) Specify the path and file name, such as **~/.ssh/id_ed25519**, of the new SSH key. If you have an existing key pair, ensure your public key is in the your **~/.ssh** directory.

NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS validated or Modules In Process cryptographic libraries on the **x86_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the ~/**.ssh/id_ed25519.pub** public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the **./openshift-install gather** command.

NOTE

On some distributions, default SSH private key identities such as ~/**.ssh/id_rsa** and ~/**.ssh/id_dsa** are managed automatically.

a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

Example output

```
Agent pid 31874
```

NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

1 Specify the path and file name for your SSH private key, such as ~/**.ssh/id_ed25519**

Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

5.7.6. Creating the installation configuration file

You can customize the OpenShift Container Platform cluster you install on Amazon Web Services (AWS).

Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster. For a restricted network installation, these files are on your mirror host.
- Have the **imageContentSources** values that were generated during mirror registry creation.
- Obtain the contents of the certificate for your mirror registry.
- Obtain service principal permissions at the subscription level.

Procedure

1. Create the **install-config.yaml** file.

   a. Change to the directory that contains the installation program and run the following command:

   ```
   $ ./openshift-install create install-config --dir <installation_directory> 1
   ```

   1 For **<installation_directory>**, specify the directory name to store the files that the installation program creates.

   When specifying the directory:

   - Verify that the directory has the **execute** permission. This permission is required to run Terraform binaries under the installation directory.
   - Use an empty directory. Some installation assets, such as bootstrap X.509 certificates, have short expiration intervals, therefore you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

   b. At the prompts, provide the configuration details for your cloud:

      i. Optional: Select an SSH key to use to access your cluster machines.

      NOTE

      For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

      ii. Select **AWS** as the platform to target.

      iii. If you do not have an Amazon Web Services (AWS) profile stored on your computer, enter the AWS access key ID and secret access key for the user that you configured to run the installation program.

      iv. Select the AWS region to deploy the cluster to.

      v. Select the base domain for the Route 53 service that you configured for your cluster.

vi. Enter a descriptive name for your cluster.

vii. Paste the pull secret from the Red Hat OpenShift Cluster Manager .

2. Edit the **install-config.yaml** file to give the additional information that is required for an installation in a restricted network.

   a. Update the **pullSecret** value to contain the authentication information for your registry:

   ```
   pullSecret: '{"auths":{"<mirror_host_name>:5000": {"auth": "<credentials>","email":
   "you@example.com"}}}'
   ```

   For **<mirror_host_name>**, specify the registry domain name that you specified in the certificate for your mirror registry, and for **<credentials>**, specify the base64-encoded user name and password for your mirror registry.

   b. Add the **additionalTrustBundle** parameter and value.

   ```
   additionalTrustBundle: |
     -----BEGIN CERTIFICATE-----

   ZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZ
     -----END CERTIFICATE-----
   ```

   The value must be the contents of the certificate file that you used for your mirror registry. The certificate file can be an existing, trusted certificate authority, or the self-signed certificate that you generated for the mirror registry.

   c. Define the subnets for the VPC to install the cluster in:

   ```
   subnets:
   - subnet-1
   - subnet-2
   - subnet-3
   ```

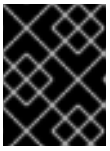
   d. Add the image content resources, which resemble the following YAML excerpt:

   ```
   imageContentSources:
   - mirrors:
     - <mirror_host_name>:5000/<repo_name>/release
     source: quay.io/openshift-release-dev/ocp-release
   - mirrors:
     - <mirror_host_name>:5000/<repo_name>/release
     source: registry.redhat.io/ocp/release
   ```

   For these values, use the **imageContentSources** that you recorded during mirror registry creation.

3. Make any other modifications to the **install-config.yaml** file that you require. You can find more information about the available parameters in the **Installation configuration parameters** section.

4. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.

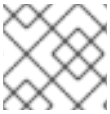


IMPORTANT

The **install-config.yaml** file is consumed during the installation process. If you want to reuse the file, you must back it up now.

5.7.6.1. Installation configuration parameters

Before you deploy an OpenShift Container Platform cluster, you provide parameter values to describe your account on the cloud platform that hosts your cluster and optionally customize your cluster's platform. When you create the **install-config.yaml** installation configuration file, you provide values for the required parameters through the command line. If you customize your cluster, you can modify the **install-config.yaml** file to provide more details about the platform.



NOTE

After installation, you cannot modify these parameters in the **install-config.yaml** file.

5.7.6.1.1. Required configuration parameters

Required installation configuration parameters are described in the following table:

Table 5.18. Required parameters

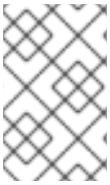
Parameter	Description	Values
apiVersion	The API version for the **install-config.yaml** content. The current version is **v1**. The installer may also support older API versions.	String
baseDomain	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the **baseDomain** and **metadata.name** parameter values that uses the **<metadata.name>.<baseDomain>** format.	A fully-qualified domain or subdomain name, such as **example.com**.
metadata	Kubernetes resource **ObjectMeta**, from which only the **name** parameter is consumed.	Object

Parameter	Description	Values
metadata.name	The name of the cluster. DNS records for the cluster are all subdomains of **{{.metadata.name}}.{{.baseDomain}}**.	String of lowercase letters, hyphens (**-**), and periods (**.**), such as **dev**.
platform	The configuration for the specific platform upon which to perform the installation: **alibabacloud**, **aws**, **baremetal**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**. For additional information about **platform.<platform>** parameters, consult the table for your specific platform that follows.	Object
pullSecret	Get a pull secret from the Red Hat OpenShift Cluster Manager to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	<pre>{ "auths":{ "cloud.openshift.com":{ "auth":"b3Blb=", "email":"you@example.com" }, "quay.io":{ "auth":"b3Blb=", "email":"you@example.com" } } }</pre>

5.7.6.1.2. Network configuration parameters

You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

Only IPv4 addresses are supported.



NOTE

Globalnet is not supported with Red Hat OpenShift Data Foundation disaster recovery solutions. For regional disaster recovery scenarios, ensure that you use a nonoverlapping range of private IP addresses for the cluster and service networks in each cluster.

Table 5.19. Network parameters

Parameter	Description	Values
networking	The configuration for the cluster network.	Object  **NOTE** You cannot modify parameters specified by the **networking** object after installation.
networking.networkType	The cluster network provider Container Network Interface (CNI) cluster network provider to install.	Either **OpenShiftSDN** or **OVNKubernetes**. **OpenShiftSDN** is a CNI provider for all-Linux networks. **OVNKubernetes** is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is **OpenShiftSDN**.
networking.clusterNetwork	The IP address blocks for pods. The default value is **10.128.0.0/14** with a host prefix of **/23**. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: `networking:` `  clusterNetwork:` `  - cidr: 10.128.0.0/14` `    hostPrefix: 23`
networking.clusterNetwork.cidr	Required if you use **networking.clusterNetwork**. An IP address block. An IPv4 network.	An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between **0** and **32**.
networking.clusterNetwork.hostPrefix	The subnet prefix length to assign to each individual node. For example, if **hostPrefix** is set to **23** then each node is assigned a **/23** subnet out of the given **cidr**. A **hostPrefix** value of **23** provides 510 (2^(32 - 23) - 2) pod IP addresses.	A subnet prefix. The default value is **23**.
networking.serviceNetwork	The IP address block for services. The default value is **172.30.0.0/16**. The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.	An array with an IP address block in CIDR format. For example: `networking:` `  serviceNetwork:` `  - 172.30.0.0/16`

Parameter	Description	Values
networking.machineNetwork	The IP address blocks for machines. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: `networking:` `  machineNetwork:` `  - cidr: 10.0.0.0/16`
networking.machineNetwork.cidr	Required if you use **networking.machineNetwork**. An IP address block. The default value is **10.0.0.0/16** for all platforms other than libvirt. For libvirt, the default value is **192.168.126.0/24**.	An IP network block in CIDR notation. For example, **10.0.0.0/16**. **NOTE** Set the **networking.machineNetwork** to match the CIDR that the preferred NIC resides in.

5.7.6.1.3. Optional configuration parameters

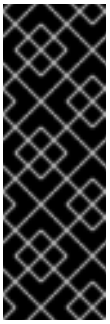
Optional installation configuration parameters are described in the following table:

Table 5.20. Optional parameters

Parameter	Description	Values
additionalTrustBundle	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String
capabilities	Controls the installation of optional core cluster components. You can reduce the footprint of your OpenShift Container Platform cluster by disabling optional components.	String array

Parameter	Description	Values
capabilities.baselineCapabilitySet	Selects an initial set of optional capabilities to enable. Valid values are **None**, **v4.11** and **vCurrent**. **v4.11** enables the **baremetal** Operator, the **marketplace** Operator, and the **openshift-samples** content. **vCurrent** installs the recommended set of capabilities for the current version of OpenShift Container Platform. The default value is **vCurrent**.	String
capabilities.additionalEnabledCapabilities	Extends the set of optional capabilities beyond what you specify in **baselineCapabilitySet**. Valid values are **baremetal**, **marketplace** and **openshift-samples**. You may specify multiple capabilities in this parameter.	String array
cgroupsV2	Enables Linux control groups version 2 (cgroups v2) on specific nodes in your cluster. The OpenShift Container Platform process for enabling cgroups v2 disables all cgroup version 1 controllers and hierarchies. The OpenShift Container Platform cgroups version 2 feature is in Developer Preview and is not supported by Red Hat at this time.	**true**
compute	The configuration for the machines that comprise the compute nodes.	Array of **MachinePool** objects.
compute.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** and **arm64**. Not all installation options support the 64-bit ARM architecture. To verify if your installation option is supported on your platform, see *Supported installation methods for different platforms* in *Selecting a cluster installation method and preparing it for users*.	String

Parameter	Description	Values
compute.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  **IMPORTANT** If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
compute.name	Required if you use **compute**. The name of the machine pool.	**worker**
compute.platform	Required if you use **compute**. Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the **controlPlane.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
compute.replicas	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to **2**. The default value is **3**.
controlPlane	The configuration for the machines that comprise the control plane.	Array of **MachinePool** objects.

Parameter	Description	Values
controlPlane.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** and **arm64**. Not all installation options support the 64-bit ARM architecture. To verify if your installation option is supported on your platform, see *Supported installation methods for different platforms* in *Selecting a cluster installation method and preparing it for users*.	String
controlPlane.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  IMPORTANT If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
controlPlane.name	Required if you use **controlPlane**. The name of the machine pool.	**master**
controlPlane.platform	Required if you use **controlPlane**. Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the **compute.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
controlPlane.replicas	The number of control plane machines to provision.	The only supported value is **3**, which is the default value.

Parameter	Description	Values
credentialsMode	The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported.  **NOTE** Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the *Cloud Credential Operator* entry in the *Cluster Operators reference* content.  **NOTE** If your AWS account has service control policies (SCP) enabled, you must configure the **credentialsMode** parameter to **Mint**, **Passthrough** or **Manual**.	**Mint**, **Passthrough**, **Manual** or an empty string (**""**).

Parameter	Description	Values
fips	Enable or disable FIPS mode. The default is **false** (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.  **IMPORTANT** To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.  **NOTE** If you are using Azure File storage, you cannot enable FIPS mode.	**false** or **true**
imageContentSources	Sources and repositories for the release-image content.	Array of objects. Includes a **source** and, optionally, **mirrors**, as described in the following rows of this table.
imageContentSources.source	Required if you use **imageContentSources**. Specify the repository that users refer to, for example, in image pull specifications.	String

Parameter	Description	Values
imageContentSources.mirrors	Specify one or more repositories that may also contain the same images.	Array of strings
publish	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	**Internal** or **External**. To deploy a private cluster, which cannot be accessed from the internet, set **publish** to **Internal**. The default value is **External**.
sshKey	The SSH key to authenticate access to your cluster machines.  **NOTE** For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.	For example, **sshKey: ssh-ed25519 AAAA..**.

5.7.6.1.4. Optional AWS configuration parameters

Optional AWS configuration parameters are described in the following table:

Table 5.21. Optional AWS parameters

Parameter	Description	Values
compute.platform.aws.amiID	The AWS AMI used to boot compute machines for the cluster. This is required for regions that require a custom RHCOS AMI.	Any published or custom RHCOS AMI that belongs to the set AWS region. See *RHCOS AMIs for AWS infrastructure* for available AMI IDs.

Parameter	Description	Values
compute.platform.aws.iamRole	A pre-existing AWS IAM role applied to the compute machine pool instance profiles. You can use these fields to match naming schemes and include predefined permissions boundaries for your IAM roles. If undefined, the installation program creates a new IAM role.	The name of a valid AWS IAM role.
compute.platform.aws.rootVolume.iops	The Input/Output Operations Per Second (IOPS) that is reserved for the root volume.	Integer, for example **4000**.
compute.platform.aws.rootVolume.size	The size in GiB of the root volume.	Integer, for example **500**.
compute.platform.aws.rootVolume.type	The type of the root volume.	Valid AWS EBS volume type, such as **io1**.
compute.platform.aws.rootVolume.kmsKeyARN	The Amazon Resource Name (key ARN) of a KMS key. This is required to encrypt OS volumes of worker nodes with a specific KMS key.	Valid key ID or the key ARN
compute.platform.aws.type	The EC2 instance type for the compute machines.	Valid AWS instance type, such as **m4.2xlarge**. See the **Supported AWS machine types** table that follows.
compute.platform.aws.zones	The availability zones where the installation program creates machines for the compute machine pool. If you provide your own VPC, you must provide a subnet in that availability zone.	A list of valid AWS availability zones, such as **us-east-1c**, in a YAML sequence.

Parameter	Description	Values
compute.aws.region	The AWS region that the installation program creates compute resources in.	Any valid AWS region, such as **us-east-1**. You can use the AWS CLI to access the regions available based on your selected instance type. For example: `aws ec2 describe-instance-type-offerings --filters Name=instance-type,Values=c7g.xlarge`  **IMPORTANT** When running on ARM based AWS instances, ensure that you enter a region where AWS Graviton processors are available. See Global availability map in the AWS documentation. Currently, AWS Graviton3 processors are only available in some regions.
controlPlane.platform.aws.amiID	The AWS AMI used to boot control plane machines for the cluster. This is required for regions that require a custom RHCOS AMI.	Any published or custom RHCOS AMI that belongs to the set AWS region. See *RHCOS AMIs for AWS infrastructure* for available AMI IDs.
controlPlane.platform.aws.iamRole	A pre-existing AWS IAM role applied to the control plane machine pool instance profiles. You can use these fields to match naming schemes and include predefined permissions boundaries for your IAM roles. If undefined, the installation program creates a new IAM role.	The name of a valid AWS IAM role.
controlPlane.platform.aws.rootVolume.kmsKeyARN	The Amazon Resource Name (key ARN) of a KMS key. This is required to encrypt OS volumes of control plane nodes with a specific KMS key.	Valid key ID and the key ARN.
controlPlane.platform.aws.type	The EC2 instance type for the control plane machines.	Valid AWS instance type, such as **m6i.xlarge**. See the **Supported AWS machine types** table that follows.

Parameter	Description	Values
controlPlane.platform.aws.zones	The availability zones where the installation program creates machines for the control plane machine pool.	A list of valid AWS availability zones, such as **us-east-1c**, in a YAML sequence.
controlPlane.aws.region	The AWS region that the installation program creates control plane resources in.	Valid AWS region, such as **us-east-1**.
platform.aws.amiID	The AWS AMI used to boot all machines for the cluster. If set, the AMI must belong to the same region as the cluster. This is required for regions that require a custom RHCOS AMI.	Any published or custom RHCOS AMI that belongs to the set AWS region. See *RHCOS AMIs for AWS infrastructure* for available AMI IDs.
platform.aws.hostedZone	An existing Route 53 private hosted zone for the cluster. You can only use a pre-existing hosted zone when also supplying your own VPC. The hosted zone must already be associated with the user-provided VPC before installation. Also, the domain of the hosted zone must be the cluster domain or a parent of the cluster domain. If undefined, the installation program creates a new hosted zone.	String, for example **Z3URY6TWQ91KVV**.
platform.aws.serviceEndpoints.name	The AWS service endpoint name. Custom endpoints are only required for cases where alternative AWS endpoints, like FIPS, must be used. Custom API endpoints can be specified for EC2, S3, IAM, Elastic Load Balancing, Tagging, Route 53, and STS AWS services.	Valid AWS service endpoint name.
platform.aws.serviceEndpoints.url	The AWS service endpoint URL. The URL must use the **https** protocol and the host must trust the certificate.	Valid AWS service endpoint URL.

Parameter	Description	Values
platform.aws.userTags	A map of keys and values that the installation program adds as tags to all resources that it creates.	Any valid YAML map, such as key value pairs in the **<key>: <value>** format. For more information about AWS tags, see Tagging Your Amazon EC2 Resources in the AWS documentation.
platform.aws.subnets	If you provide the VPC instead of allowing the installation program to create the VPC for you, specify the subnet for the cluster to use. The subnet must be part of the same **machineNetwork[].cidr** ranges that you specify. For a standard cluster, specify a public and a private subnet for each availability zone. For a private cluster, specify a private subnet for each availability zone.	Valid subnet IDs.

5.7.6.2. Minimum resource requirements for cluster installation

Each cluster machine must meet the following minimum requirements:

Table 5.22. Minimum resource requirements

Machine	Operating System	vCPU [1]	Virtual RAM	Storage	IOPS [2]
Bootstrap	RHCOS	4	16 GB	100 GB	300
Control plane	RHCOS	4	16 GB	100 GB	300
Compute	RHCOS, RHEL 8.6 and later [3]	2	8 GB	100 GB	300

1. One vCPU is equivalent to one physical core when simultaneous multithreading (SMT), or hyperthreading, is not enabled. When enabled, use the following formula to calculate the corresponding ratio: (threads per core × cores) × sockets = vCPUs.

2. OpenShift Container Platform and Kubernetes are sensitive to disk performance, and faster storage is recommended, particularly for etcd on the control plane nodes which require a 10 ms p99 fsync duration. Note that on many cloud platforms, storage size and IOPS scale together, so you might need to over-allocate storage volume to obtain sufficient performance.

3. As with all user-provisioned installations, if you choose to use RHEL compute machines in your cluster, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks.

Use of RHEL 7 compute machines is deprecated and has been removed in OpenShift Container Platform 4.10 and later.

If an instance type for your platform meets the minimum requirements for cluster machines, it is supported to use in OpenShift Container Platform.

Additional resources

- Optimizing storage

5.7.6.3. Sample customized install-config.yaml file for AWS

You can customize the installation configuration file (**install-config.yaml**) to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.

IMPORTANT

This sample YAML file is provided for reference only. You must obtain your **install-config.yaml** file by using the installation program and modify it.

```
apiVersion: v1
baseDomain: example.com (1)
credentialsMode: Mint (2)
controlPlane: (3) (4)
  hyperthreading: Enabled (5)
  name: master
  platform:
    aws:
      zones:
      - us-west-2a
      - us-west-2b
      rootVolume:
        iops: 4000
        size: 500
        type: io1 (6)
      metadataService:
        authentication: Optional (7)
      type: m6i.xlarge
  replicas: 3
compute: (8)
- hyperthreading: Enabled (9)
  name: worker
  platform:
    aws:
      rootVolume:
        iops: 2000
        size: 500
        type: io1 (10)
      metadataService:
        authentication: Optional (11)
      type: c5.4xlarge
      zones:
      - us-west-2c
```

```
  replicas: 3
metadata:
  name: test-cluster 12
networking:
  clusterNetwork:
  - cidr: 10.128.0.0/14
    hostPrefix: 23
  machineNetwork:
  - cidr: 10.0.0.0/16
  networkType: OpenShiftSDN
  serviceNetwork:
  - 172.30.0.0/16
platform:
  aws:
    region: us-west-2 13
    userTags:
      adminContact: jdoe
      costCenter: 7536
    subnets: 14
    - subnet-1
    - subnet-2
    - subnet-3
    amiID: ami-96c6f8f7 15
    serviceEndpoints: 16
      - name: ec2
        url: https://vpce-id.ec2.us-west-2.vpce.amazonaws.com
    hostedZone: Z3URY6TWQ91KVV 17
fips: false 18
sshKey: ssh-ed25519 AAAA... 19
pullSecret: '{"auths":{"<local_registry>": {"auth": "<credentials>","email": "you@example.com"}}}' 20
additionalTrustBundle: | 21
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
imageContentSources: 22
- mirrors:
  - <local_registry>/<local_repository_name>/release
  source: quay.io/openshift-release-dev/ocp-release
- mirrors:
  - <local_registry>/<local_repository_name>/release
  source: quay.io/openshift-release-dev/ocp-v4.0-art-dev
```

1 12 13 Required. The installation program prompts you for this value.

2 Optional: Add this parameter to force the Cloud Credential Operator (CCO) to use the specified mode, instead of having the CCO dynamically try to determine the capabilities of the credentials. For details about CCO modes, see the *Cloud Credential Operator* entry in the *Red Hat Operators reference* content.

3 8 If you do not provide these parameters and values, the installation program provides the default value.

4 The **controlPlane** section is a single mapping, but the **compute** section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, **-**, and the first line of the **controlPlane** section must not. Only one

control plane pool is used.

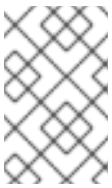
5 9 Whether to enable or disable simultaneous multithreading, or **hyperthreading**. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores. You can disable it by setting the parameter value to **Disabled**. If you disable simultaneous multithreading in some cluster machines, you must disable it in all cluster machines.

IMPORTANT

If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance. Use larger instance types, such as **m4.2xlarge** or **m5.2xlarge**, for your machines if you disable simultaneous multithreading.

6 10 To configure faster storage for etcd, especially for larger clusters, set the storage type as **io1** and set **iops** to **2000**.

7 11 Whether to require the Amazon EC2 Instance Metadata Service v2 (IMDSv2). To require IMDSv2, set the parameter value to **Required**. To allow the use of both IMDSv1 and IMDSv2, set the parameter value to **Optional**. If no value is specified, both IMDSv1 and IMDSv2 are allowed.



NOTE

The IMDS configuration for control plane machines that is set during cluster installation can only be changed by using the AWS CLI. The IMDS configuration for compute machines can be changed by using machine sets.

14 If you provide your own VPC, specify subnets for each availability zone that your cluster uses.

15 The ID of the AMI used to boot machines for the cluster. If set, the AMI must belong to the same region as the cluster.

16 The AWS service endpoints. Custom endpoints are required when installing to an unknown AWS region. The endpoint URL must use the **https** protocol and the host must trust the certificate.

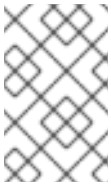
17 The ID of your existing Route 53 private hosted zone. Providing an existing hosted zone requires that you supply your own VPC and the hosted zone is already associated with the VPC prior to installing your cluster. If undefined, the installation program creates a new hosted zone.

18 Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.

IMPORTANT

To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.

19 You can optionally provide the **sshKey** value that you use to access the machines in your cluster.



NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

20 For **<local_registry>**, specify the registry domain name, and optionally the port, that your mirror registry uses to serve content. For example **registry.example.com** or **registry.example.com:5000**. For **<credentials>**, specify the base64-encoded user name and password for your mirror registry.

21 Provide the contents of the certificate file that you used for your mirror registry.

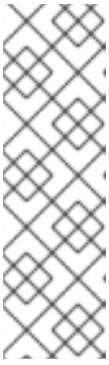
22 Provide the **imageContentSources** section from the output of the command to mirror the repository.

5.7.6.4. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.



NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: ec2.<region>.amazonaws.com,elasticloadbalancing.
<region>.amazonaws.com,s3.<region>.amazonaws.com 3
```

```
additionalTrustBundle: | 4
  -----BEGIN CERTIFICATE-----
  <MY_TRUSTED_CA_CERT>
  -----END CERTIFICATE-----
```

1. A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
2. A proxy URL to use for creating HTTPS connections outside the cluster.
3. A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use * to bypass the proxy for all destinations. If you have added the Amazon **EC2**,**Elastic Load Balancing**, and **S3** VPC endpoints to your VPC, you must add these endpoints to the **noProxy** field.
4. If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace that contains one or more additional CA certificates that are required for proxying HTTPS connections. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges these contents with the Red Hat Enterprise Linux CoreOS (RHCOS) trust bundle, and this config map is referenced in the **trustedCA** field of the **Proxy** object. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.

NOTE

The installation program does not support the proxy **readinessEndpoints** field.

NOTE

If the installer times out, restart and then complete the deployment by using the **wait-for** command of the installer. For example:

```
$ ./openshift-install wait-for install-complete --log-level debug
```

2. Save the file and reference it when installing OpenShift Container Platform.

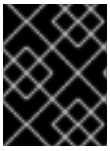
The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.

NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

5.7.7. Deploying the cluster

You can install OpenShift Container Platform on a compatible cloud platform.



IMPORTANT

You can run the **create cluster** command of the installation program only once, during initial installation.

Prerequisites

- Configure an account with the cloud platform that hosts your cluster.
- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.

Procedure

1. Change to the directory that contains the installation program and initialize the cluster deployment:

```
$ ./openshift-install create cluster --dir <installation_directory> \ 1
    --log-level=info 2
```

1 For **<installation_directory>**, specify the location of your customized **./install-config.yaml** file.

2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

NOTE

If the cloud provider account that you configured on your host does not have sufficient permissions to deploy the cluster, the installation process stops, and the missing permissions are displayed.

2. Optional: Remove or disable the **AdministratorAccess** policy from the IAM account that you used to install the cluster.

NOTE

The elevated permissions provided by the **AdministratorAccess** policy are required only during installation.

Verification

When the cluster deployment completes successfully:

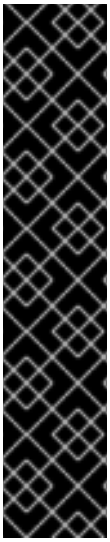
- The terminal displays directions for accessing your cluster, including a link to the web console and credentials for the **kubeadmin** user.
- Credential information also outputs to **<installation_directory>/.openshift_install.log**.

IMPORTANT

Do not delete the installation program or the files that the installation program creates. Both are required to delete the cluster.

Example output

```
...
INFO Install complete!
INFO To access the cluster as the system:admin user when using 'oc', run 'export
KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
INFO Access the OpenShift web-console here: https://console-openshift-
console.apps.mycluster.example.com
INFO Login to the console with user: "kubeadmin", and password: "password"
INFO Time elapsed: 36m22s
```

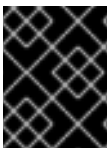


IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

5.7.8. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.



IMPORTANT

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.11. Download and install the new version of **oc**.

Installing the OpenShift CLI on Linux

You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the architecture in the **Product Variant** drop-down menu.
3. Select the appropriate version in the **Version** drop-down menu.
4. Click **Download Now** next to the **OpenShift v4.11 Linux Client** entry and save the file.
5. Unpack the archive:

```
$ tar xvf <file>
```

6. Place the **oc** binary in a directory that is on your **PATH**.
   To check your **PATH**, execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.
   To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
C:\> oc <command>
```

Installing the OpenShift CLI on macOS

You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 macOS Client** entry and save the file.

NOTE

For macOS arm64, choose the **OpenShift v4.11 macOS arm64 Client** entry.

4. Unpack and unzip the archive.

5. Move the **oc** binary to a directory on your PATH.
   To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

5.7.9. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

   1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

Example output

```
system:admin
```

5.7.10. Disabling the default OperatorHub sources

Operator catalogs that source content provided by Red Hat and community projects are configured for OperatorHub by default during an OpenShift Container Platform installation. In a restricted network environment, you must disable the default catalogs as a cluster administrator.

Procedure

- Disable the sources for the default catalogs by adding **disableAllDefaultSources: true** to the **OperatorHub** object:

```
$ oc patch OperatorHub cluster --type json \
    -p '[{"op": "add", "path": "/spec/disableAllDefaultSources", "value": true}]'
```

TIP

Alternatively, you can use the web console to manage catalog sources. From the **Administration → Cluster Settings → Configuration → OperatorHub** page, click the **Sources** tab, where you can create, update, delete, disable, and enable individual sources.

5.7.11. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.11, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to OpenShift Cluster Manager Hybrid Cloud Console.

After you confirm that your OpenShift Cluster Manager Hybrid Cloud Console inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, use subscription watch to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

Additional resources

- See About remote health monitoring for more information about the Telemetry service

5.7.12. Next steps

- Validate an installation.
- Customize your cluster.
- Configure image streams for the Cluster Samples Operator and the **must-gather** tool.
- Learn how to use Operator Lifecycle Manager (OLM) on restricted networks .
- If the mirror registry that you used to install your cluster has a trusted CA, add it to the cluster by configuring additional trust stores.
- If necessary, you can opt out of remote health reporting .

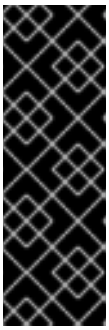
5.8. INSTALLING A CLUSTER ON AWS INTO AN EXISTING VPC

In OpenShift Container Platform version 4.11, you can install a cluster into an existing Amazon Virtual Private Cloud (VPC) on Amazon Web Services (AWS). The installation program provisions the rest of the required infrastructure, which you can further customize. To customize the installation, you modify parameters in the **install-config.yaml** file before you install the cluster.

5.8.1. Prerequisites

- You reviewed details about the OpenShift Container Platform installation and update processes.
- You read the documentation on selecting a cluster installation method and preparing it for users.

- You configured an AWS account to host the cluster.



IMPORTANT

If you have an AWS profile stored on your computer, it must not use a temporary session token that you generated while using a multi-factor authentication device. The cluster continues to use your current AWS credentials to create AWS resources for the entire life of the cluster, so you must use long-lived credentials. To generate appropriate keys, see Managing Access Keys for IAM Users in the AWS documentation. You can supply the keys when you run the installation program.

- If you use a firewall, you configured it to allow the sites that your cluster requires access to.
- If the cloud identity and access management (IAM) APIs are not accessible in your environment, or if you do not want to store an administrator-level credential secret in the **kube-system** namespace, you can manually create and maintain IAM credentials.

5.8.2. About using a custom VPC

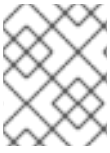
In OpenShift Container Platform 4.11, you can deploy a cluster into existing subnets in an existing Amazon Virtual Private Cloud (VPC) in Amazon Web Services (AWS). By deploying OpenShift Container Platform into an existing AWS VPC, you might be able to avoid limit constraints in new accounts or more easily abide by the operational constraints that your company's guidelines set. If you cannot obtain the infrastructure creation permissions that are required to create the VPC yourself, use this installation option.

Because the installation program cannot know what other components are also in your existing subnets, it cannot choose subnet CIDRs and so forth on your behalf. You must configure networking for the subnets that you install your cluster to yourself.

5.8.2.1. Requirements for using your VPC

The installation program no longer creates the following components:

- Internet gateways
- NAT gateways
- Subnets
- Route tables
- VPCs
- VPC DHCP options
- VPC endpoints



NOTE

The installation program requires that you use the cloud-provided DNS server. Using a custom DNS server is not supported and causes the installation to fail.

If you use a custom VPC, you must correctly configure it and its subnets for the installation program and the cluster to use. See Amazon VPC console wizard configurations and Work with VPCs and subnets in the AWS documentation for more information on creating and managing an AWS VPC.

The installation program cannot:

- Subdivide network ranges for the cluster to use.
- Set route tables for the subnets.
- Set VPC options like DHCP.

You must complete these tasks before you install the cluster. See VPC networking components and Route tables for your VPC for more information on configuring networking in an AWS VPC.

Your VPC must meet the following characteristics:

- Create a public and private subnet for each availability zone that your cluster uses. Each availability zone can contain no more than one public and one private subnet. For an example of this type of configuration, see VPC with public and private subnets (NAT) in the AWS documentation.
  Record each subnet ID. Completing the installation requires that you enter these values in the **platform** section of the **install-config.yaml** file. See Finding a subnet ID in the AWS documentation.
- The VPC's CIDR block must contain the **Networking.MachineCIDR** range, which is the IP address pool for cluster machines. The subnet CIDR blocks must belong to the machine CIDR that you specify.
- The VPC must have a public internet gateway attached to it. For each availability zone:
  - The public subnet requires a route to the internet gateway.
  - The public subnet requires a NAT gateway with an EIP address.
  - The private subnet requires a route to the NAT gateway in public subnet.
- The VPC must not use the **kubernetes.io/cluster/.*: owned**, **Name**, and **openshift.io/cluster** tags.
  The installation program modifies your subnets to add the **kubernetes.io/cluster/.*: shared** tag, so your subnets must have at least one free tag slot available for it. See Tag Restrictions in the AWS documentation to confirm that the installation program can add a tag to each subnet that you specify. You cannot use a **Name** tag, because it overlaps with the EC2 **Name** field and the installation fails.
- You must enable the **enableDnsSupport** and **enableDnsHostnames** attributes in your VPC, so that the cluster can use the Route 53 zones that are attached to the VPC to resolve cluster's internal DNS records. See DNS Support in Your VPC in the AWS documentation.
  If you prefer to use your own Route 53 hosted private zone, you must associate the existing hosted zone with your VPC prior to installing a cluster. You can define your hosted zone using the **platform.aws.hostedZone** field in the **install-config.yaml** file.

If you are working in a disconnected environment, you are unable to reach the public IP addresses for EC2, ELB, and S3 endpoints. Depending on the level to which you want to restrict internet traffic during the installation, the following configuration options are available:

Option 1: Create VPC endpoints

Create a VPC endpoint and attach it to the subnets that the clusters are using. Name the endpoints as follows:

- **ec2.<region>.amazonaws.com**
- **elasticloadbalancing.<region>.amazonaws.com**
- **s3.<region>.amazonaws.com**

With this option, network traffic remains private between your VPC and the required AWS services.

Option 2: Create a proxy without VPC endpoints
As part of the installation process, you can configure an HTTP or HTTPS proxy. With this option, internet traffic goes through the proxy to reach the required AWS services.

Option 3: Create a proxy with VPC endpoints
As part of the installation process, you can configure an HTTP or HTTPS proxy with VPC endpoints. Create a VPC endpoint and attach it to the subnets that the clusters are using. Name the endpoints as follows:

- **ec2.<region>.amazonaws.com**
- **elasticloadbalancing.<region>.amazonaws.com**
- **s3.<region>.amazonaws.com**

When configuring the proxy in the **install-config.yaml** file, add these endpoints to the **noProxy** field. With this option, the proxy prevents the cluster from accessing the internet directly. However, network traffic remains private between your VPC and the required AWS services.

Required VPC components

You must provide a suitable VPC and subnets that allow communication to your machines.

Component	AWS type	Description
VPC	• **AWS::EC2::VPC** • **AWS::EC2::VPCEndpoint**	You must provide a public VPC for the cluster to use. The VPC uses an endpoint that references the route tables for each subnet to improve communication with the registry that is hosted in S3.
Public subnets	• **AWS::EC2::Subnet** • **AWS::EC2::SubnetNetworkAclAssociation**	Your VPC must have public subnets for between 1 and 3 availability zones and associate them with appropriate Ingress rules.

<table>
<tr><th>Component</th><th>AWS type</th><th>Description</th></tr>
<tr><td>Internet gateway</td><td>AWS::EC2::InternetGateway
AWS::EC2::VPCGatewayAttachment
AWS::EC2::RouteTable
AWS::EC2::Route
AWS::EC2::SubnetRouteTableAssociation
AWS::EC2::NatGateway
AWS::EC2::EIP</td><td>You must have a public internet gateway, with public routes, attached to the VPC. In the provided templates, each public subnet has a NAT gateway with an EIP address. These NAT gateways allow cluster resources, like private subnet instances, to reach the internet and are not required for some restricted network or proxy scenarios.</td></tr>
<tr><td>Network access control</td><td>AWS::EC2::NetworkAcl
AWS::EC2::NetworkAclEntry</td><td>You must allow the VPC to access the following ports:<table><tr><th>Port</th><th>Reason</th></tr><tr><td>80</td><td>Inbound HTTP traffic</td></tr><tr><td>443</td><td>Inbound HTTPS traffic</td></tr><tr><td>22</td><td>Inbound SSH traffic</td></tr><tr><td>1024 - 65535</td><td>Inbound ephemeral traffic</td></tr><tr><td>0 - 65535</td><td>Outbound ephemeral traffic</td></tr></table></td></tr>
<tr><td>Private subnets</td><td>AWS::EC2::Subnet
AWS::EC2::RouteTable
AWS::EC2::SubnetRouteTableAssociation</td><td>Your VPC can have private subnets. The provided CloudFormation templates can create private subnets for between 1 and 3 availability zones. If you use private subnets, you must provide appropriate routes and tables for them.</td></tr>
</table>

5.8.2.2. VPC validation

To ensure that the subnets that you provide are suitable, the installation program confirms the following data:

- All the subnets that you specify exist.
- You provide private subnets.
- The subnet CIDRs belong to the machine CIDR that you specified.
- You provide subnets for each availability zone. Each availability zone contains no more than one public and one private subnet. If you use a private cluster, provide only a private subnet for each availability zone. Otherwise, provide exactly one public and private subnet for each availability zone.
- You provide a public subnet for each private subnet availability zone. Machines are not provisioned in availability zones that you do not provide private subnets for.

If you destroy a cluster that uses an existing VPC, the VPC is not deleted. When you remove the OpenShift Container Platform cluster from a VPC, the **kubernetes.io/cluster/.*: shared** tag is removed from the subnets that it used.

5.8.2.3. Division of permissions

Starting with OpenShift Container Platform 4.3, you do not need all of the permissions that are required for an installation program-provisioned infrastructure cluster to deploy a cluster. This change mimics the division of permissions that you might have at your company: some individuals can create different resource in your clouds than others. For example, you might be able to create application-specific items, like instances, buckets, and load balancers, but not networking-related components such as VPCs, subnets, or ingress rules.

The AWS credentials that you use when you create your cluster do not need the networking permissions that are required to make VPCs and core networking components within the VPC, such as subnets, routing tables, internet gateways, NAT, and VPN. You still need permission to make the application resources that the machines within the cluster require, such as ELBs, security groups, S3 buckets, and nodes.

5.8.2.4. Isolation between clusters

If you deploy OpenShift Container Platform to an existing network, the isolation of cluster services is reduced in the following ways:

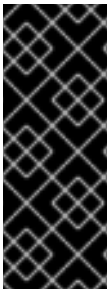
- You can install multiple OpenShift Container Platform clusters in the same VPC.
- ICMP ingress is allowed from the entire network.
- TCP 22 ingress (SSH) is allowed to the entire network.
- Control plane TCP 6443 ingress (Kubernetes API) is allowed to the entire network.
- Control plane TCP 22623 ingress (MCS) is allowed to the entire network.

5.8.3. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.11, you require access to the internet to install your cluster.

You must have internet access to:

- Access OpenShift Cluster Manager Hybrid Cloud Console to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access Quay.io to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.



IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

5.8.4. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the **~/.ssh/authorized_keys** list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The **./openshift-install gather** command also requires the SSH public key to be in place on the cluster nodes.

IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.

NOTE

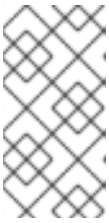
You must use a local key, not one that you configured with platform-specific approaches such as AWS key pairs.

Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N '' -f <path>/<file_name> 1
```

1. Specify the path and file name, such as **~/.ssh/id_ed25519**, of the new SSH key. If you have an existing key pair, ensure your public key is in the your **~/.ssh** directory.



NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS validated or Modules In Process cryptographic libraries on the **x86_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the ~/**.ssh/id_ed25519.pub** public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the **./openshift-install gather** command.

NOTE

On some distributions, default SSH private key identities such as ~/**.ssh/id_rsa** and ~/**.ssh/id_dsa** are managed automatically.

a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

Example output

```
Agent pid 31874
```

NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> (1)
```

(1) Specify the path and file name for your SSH private key, such as ~/**.ssh/id_ed25519**

Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

5.8.5. Obtaining the installation program

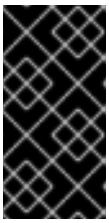
Before you install OpenShift Container Platform, download the installation file on a local computer.

Prerequisites

- You have a computer that runs Linux or macOS, with 500 MB of local disk space.

Procedure

1. Access the Infrastructure Provider page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program that corresponds with your host operating system and architecture, and place the file in the directory where you will store the installation configuration files.



IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.

IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation pull secret from the Red Hat OpenShift Cluster Manager . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

5.8.6. Creating the installation configuration file

You can customize the OpenShift Container Platform cluster you install on Amazon Web Services (AWS).

Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.
- Obtain service principal permissions at the subscription level.

Procedure

1. Create the **install-config.yaml** file.
   a. Change to the directory that contains the installation program and run the following command:

```
$ ./openshift-install create install-config --dir <installation_directory> 1
```

   1 For **<installation_directory>**, specify the directory name to store the files that the installation program creates.

   When specifying the directory:

   - Verify that the directory has the **execute** permission. This permission is required to run Terraform binaries under the installation directory.
   - Use an empty directory. Some installation assets, such as bootstrap X.509 certificates, have short expiration intervals, therefore you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

   b. At the prompts, provide the configuration details for your cloud:
      i. Optional: Select an SSH key to use to access your cluster machines.

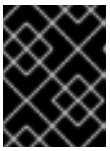
NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

      ii. Select **AWS** as the platform to target.
      iii. If you do not have an Amazon Web Services (AWS) profile stored on your computer, enter the AWS access key ID and secret access key for the user that you configured to run the installation program.
      iv. Select the AWS region to deploy the cluster to.
      v. Select the base domain for the Route 53 service that you configured for your cluster.
      vi. Enter a descriptive name for your cluster.
      vii. Paste the pull secret from the Red Hat OpenShift Cluster Manager .

2. Modify the **install-config.yaml** file. You can find more information about the available parameters in the "Installation configuration parameters" section.

3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.

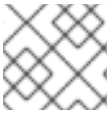


IMPORTANT

The **install-config.yaml** file is consumed during the installation process. If you want to reuse the file, you must back it up now.

5.8.6.1. Installation configuration parameters

Before you deploy an OpenShift Container Platform cluster, you provide parameter values to describe your account on the cloud platform that hosts your cluster and optionally customize your cluster's platform. When you create the **install-config.yaml** installation configuration file, you provide values for the required parameters through the command line. If you customize your cluster, you can modify the **install-config.yaml** file to provide more details about the platform.



NOTE

After installation, you cannot modify these parameters in the **install-config.yaml** file.

5.8.6.1.1. Required configuration parameters

Required installation configuration parameters are described in the following table:

Table 5.23. Required parameters

Parameter	Description	Values
apiVersion	The API version for the **install-config.yaml** content. The current version is **v1**. The installer may also support older API versions.	String
baseDomain	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the **baseDomain** and **metadata.name** parameter values that uses the **<metadata.name>.<baseDomain>** format.	A fully-qualified domain or subdomain name, such as **example.com**.
metadata	Kubernetes resource **ObjectMeta**, from which only the **name** parameter is consumed.	Object

Parameter	Description	Values
metadata.name	The name of the cluster. DNS records for the cluster are all subdomains of **{{.metadata.name}}.{{.baseDomain}}**.	String of lowercase letters, hyphens (**-**), and periods (**.**), such as **dev**.
platform	The configuration for the specific platform upon which to perform the installation: **alibabacloud**, **aws**, **baremetal**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**. For additional information about **platform.<platform>** parameters, consult the table for your specific platform that follows.	Object
pullSecret	Get a pull secret from the Red Hat OpenShift Cluster Manager to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	{ "auths":{ "cloud.openshift.com":{ "auth":"b3Blb=", "email":"you@example.com" }, "quay.io":{ "auth":"b3Blb=", "email":"you@example.com" } } }

5.8.6.1.2. Network configuration parameters

You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

Only IPv4 addresses are supported.

NOTE

Globalnet is not supported with Red Hat OpenShift Data Foundation disaster recovery solutions. For regional disaster recovery scenarios, ensure that you use a nonoverlapping range of private IP addresses for the cluster and service networks in each cluster.

Table 5.24. Network parameters

Parameter	Description	Values
networking	The configuration for the cluster network.	Object  **NOTE** You cannot modify parameters specified by the **networking** object after installation.
networking.networkType	The cluster network provider Container Network Interface (CNI) cluster network provider to install.	Either **OpenShiftSDN** or **OVNKubernetes**. **OpenShiftSDN** is a CNI provider for all-Linux networks. **OVNKubernetes** is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is **OpenShiftSDN**.
networking.clusterNetwork	The IP address blocks for pods. The default value is **10.128.0.0/14** with a host prefix of **/23**. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: `networking:` `  clusterNetwork:` `  - cidr: 10.128.0.0/14` `    hostPrefix: 23`
networking.clusterNetwork.cidr	Required if you use **networking.clusterNetwork**. An IP address block. An IPv4 network.	An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between **0** and **32**.
networking.clusterNetwork.hostPrefix	The subnet prefix length to assign to each individual node. For example, if **hostPrefix** is set to **23** then each node is assigned a **/23** subnet out of the given **cidr**. A **hostPrefix** value of **23** provides 510 (2^(32 - 23) - 2) pod IP addresses.	A subnet prefix. The default value is **23**.
networking.serviceNetwork	The IP address block for services. The default value is **172.30.0.0/16**. The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.	An array with an IP address block in CIDR format. For example: `networking:` `  serviceNetwork:` `  - 172.30.0.0/16`

Parameter	Description	Values
networking.machineNetwork	The IP address blocks for machines. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: networking: machineNetwork: - cidr: 10.0.0.0/16
networking.machineNetwork.cidr	Required if you use **networking.machineNetwork**. An IP address block. The default value is **10.0.0.0/16** for all platforms other than libvirt. For libvirt, the default value is **192.168.126.0/24**.	An IP network block in CIDR notation. For example, **10.0.0.0/16**. NOTE Set the **networking.machineNetwork** to match the CIDR that the preferred NIC resides in.

5.8.6.1.3. Optional configuration parameters

Optional installation configuration parameters are described in the following table:

Table 5.25. Optional parameters

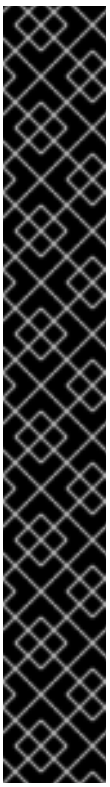
Parameter	Description	Values
additionalTrustBundle	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String
capabilities	Controls the installation of optional core cluster components. You can reduce the footprint of your OpenShift Container Platform cluster by disabling optional components.	String array

Parameter	Description	Values
capabilities.baselineCapabilitySet	Selects an initial set of optional capabilities to enable. Valid values are **None**, **v4.11** and **vCurrent**. **v4.11** enables the **baremetal** Operator, the **marketplace** Operator, and the **openshift-samples** content. **vCurrent** installs the recommended set of capabilities for the current version of OpenShift Container Platform. The default value is **vCurrent**.	String
capabilities.additionalEnabledCapabilities	Extends the set of optional capabilities beyond what you specify in **baselineCapabilitySet**. Valid values are **baremetal**, **marketplace** and **openshift-samples**. You may specify multiple capabilities in this parameter.	String array
cgroupsV2	Enables Linux control groups version 2 (cgroups v2) on specific nodes in your cluster. The OpenShift Container Platform process for enabling cgroups v2 disables all cgroup version 1 controllers and hierarchies. The OpenShift Container Platform cgroups version 2 feature is in Developer Preview and is not supported by Red Hat at this time.	**true**
compute	The configuration for the machines that comprise the compute nodes.	Array of **MachinePool** objects.
compute.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** and **arm64**. Not all installation options support the 64-bit ARM architecture. To verify if your installation option is supported on your platform, see *Supported installation methods for different platforms* in *Selecting a cluster installation method and preparing it for users*.	String

Parameter	Description	Values
compute.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  **IMPORTANT** If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
compute.name	Required if you use **compute**. The name of the machine pool.	**worker**
compute.platform	Required if you use **compute**. Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the **controlPlane.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
compute.replicas	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to **2**. The default value is **3**.
controlPlane	The configuration for the machines that comprise the control plane.	Array of **MachinePool** objects.

Parameter	Description	Values
controlPlane.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** and **arm64**. Not all installation options support the 64-bit ARM architecture. To verify if your installation option is supported on your platform, see *Supported installation methods for different platforms* in *Selecting a cluster installation method and preparing it for users*.	String
controlPlane.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  **IMPORTANT** If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
controlPlane.name	Required if you use **controlPlane**. The name of the machine pool.	**master**
controlPlane.platform	Required if you use **controlPlane**. Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the **compute.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
controlPlane.replicas	The number of control plane machines to provision.	The only supported value is **3**, which is the default value.

Parameter	Description	Values
credentialsMode	The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported.  **NOTE** Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the *Cloud Credential Operator* entry in the *Cluster Operators reference* content.  **NOTE** If your AWS account has service control policies (SCP) enabled, you must configure the **credentialsMode** parameter to **Mint**, **Passthrough** or **Manual**.	**Mint**, **Passthrough**, **Manual** or an empty string (**""**).

Parameter	Description	Values
fips	Enable or disable FIPS mode. The default is **false** (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.  **IMPORTANT** To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.  **NOTE** If you are using Azure File storage, you cannot enable FIPS mode.	**false** or **true**
imageContentSources	Sources and repositories for the release-image content.	Array of objects. Includes a **source** and, optionally, **mirrors**, as described in the following rows of this table.
imageContentSources.source	Required if you use **imageContentSources**. Specify the repository that users refer to, for example, in image pull specifications.	String

Parameter	Description	Values
imageContentSources.mirrors	Specify one or more repositories that may also contain the same images.	Array of strings
publish	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	**Internal** or **External**. To deploy a private cluster, which cannot be accessed from the internet, set **publish** to **Internal**. The default value is **External**.
sshKey	The SSH key to authenticate access to your cluster machines.  **NOTE** For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.	For example, **sshKey: ssh-ed25519 AAAA..**.

5.8.6.1.4. Optional AWS configuration parameters

Optional AWS configuration parameters are described in the following table:

Table 5.26. Optional AWS parameters

Parameter	Description	Values
compute.platform.aws.amiID	The AWS AMI used to boot compute machines for the cluster. This is required for regions that require a custom RHCOS AMI.	Any published or custom RHCOS AMI that belongs to the set AWS region. See *RHCOS AMIs for AWS infrastructure* for available AMI IDs.

Parameter	Description	Values
compute.platform.aws.iamRole	A pre-existing AWS IAM role applied to the compute machine pool instance profiles. You can use these fields to match naming schemes and include predefined permissions boundaries for your IAM roles. If undefined, the installation program creates a new IAM role.	The name of a valid AWS IAM role.
compute.platform.aws.rootVolume.iops	The Input/Output Operations Per Second (IOPS) that is reserved for the root volume.	Integer, for example **4000**.
compute.platform.aws.rootVolume.size	The size in GiB of the root volume.	Integer, for example **500**.
compute.platform.aws.rootVolume.type	The type of the root volume.	Valid AWS EBS volume type, such as **io1**.
compute.platform.aws.rootVolume.kmsKeyARN	The Amazon Resource Name (key ARN) of a KMS key. This is required to encrypt OS volumes of worker nodes with a specific KMS key.	Valid key ID or the key ARN
compute.platform.aws.type	The EC2 instance type for the compute machines.	Valid AWS instance type, such as **m4.2xlarge**. See the **Supported AWS machine types** table that follows.
compute.platform.aws.zones	The availability zones where the installation program creates machines for the compute machine pool. If you provide your own VPC, you must provide a subnet in that availability zone.	A list of valid AWS availability zones, such as **us-east-1c**, in a YAML sequence.

Parameter	Description	Values
compute.aws.region	The AWS region that the installation program creates compute resources in.	Any valid AWS region, such as **us-east-1**. You can use the AWS CLI to access the regions available based on your selected instance type. For example: `aws ec2 describe-instance-type-offerings --filters Name=instance-type,Values=c7g.xlarge`  **IMPORTANT** When running on ARM based AWS instances, ensure that you enter a region where AWS Graviton processors are available. See Global availability map in the AWS documentation. Currently, AWS Graviton3 processors are only available in some regions.
controlPlane.platform.aws.amiID	The AWS AMI used to boot control plane machines for the cluster. This is required for regions that require a custom RHCOS AMI.	Any published or custom RHCOS AMI that belongs to the set AWS region. See *RHCOS AMIs for AWS infrastructure* for available AMI IDs.
controlPlane.platform.aws.iamRole	A pre-existing AWS IAM role applied to the control plane machine pool instance profiles. You can use these fields to match naming schemes and include predefined permissions boundaries for your IAM roles. If undefined, the installation program creates a new IAM role.	The name of a valid AWS IAM role.
controlPlane.platform.aws.rootVolume.kmsKeyARN	The Amazon Resource Name (key ARN) of a KMS key. This is required to encrypt OS volumes of control plane nodes with a specific KMS key.	Valid key ID and the key ARN
controlPlane.platform.aws.type	The EC2 instance type for the control plane machines.	Valid AWS instance type, such as **m6i.xlarge**. See the **Supported AWS machine types** table that follows.

Parameter	Description	Values
controlPlane.platform.aws.zones	The availability zones where the installation program creates machines for the control plane machine pool.	A list of valid AWS availability zones, such as **us-east-1c**, in a YAML sequence.
controlPlane.aws.region	The AWS region that the installation program creates control plane resources in.	Valid AWS region, such as **us-east-1**.
platform.aws.amiID	The AWS AMI used to boot all machines for the cluster. If set, the AMI must belong to the same region as the cluster. This is required for regions that require a custom RHCOS AMI.	Any published or custom RHCOS AMI that belongs to the set AWS region. See *RHCOS AMIs for AWS infrastructure* for available AMI IDs.
platform.aws.hostedZone	An existing Route 53 private hosted zone for the cluster. You can only use a pre-existing hosted zone when also supplying your own VPC. The hosted zone must already be associated with the user-provided VPC before installation. Also, the domain of the hosted zone must be the cluster domain or a parent of the cluster domain. If undefined, the installation program creates a new hosted zone.	String, for example **Z3URY6TWQ91KVV**.
platform.aws.serviceEndpoints.name	The AWS service endpoint name. Custom endpoints are only required for cases where alternative AWS endpoints, like FIPS, must be used. Custom API endpoints can be specified for EC2, S3, IAM, Elastic Load Balancing, Tagging, Route 53, and STS AWS services.	Valid AWS service endpoint name.
platform.aws.serviceEndpoints.url	The AWS service endpoint URL. The URL must use the **https** protocol and the host must trust the certificate.	Valid AWS service endpoint URL.

Parameter	Description	Values
platform.aws.userTags	A map of keys and values that the installation program adds as tags to all resources that it creates.	Any valid YAML map, such as key value pairs in the **<key>: <value>** format. For more information about AWS tags, see Tagging Your Amazon EC2 Resources in the AWS documentation.
platform.aws.subnets	If you provide the VPC instead of allowing the installation program to create the VPC for you, specify the subnet for the cluster to use. The subnet must be part of the same **machineNetwork[].cidr** ranges that you specify. For a standard cluster, specify a public and a private subnet for each availability zone. For a private cluster, specify a private subnet for each availability zone.	Valid subnet IDs.

5.8.6.2. Minimum resource requirements for cluster installation

Each cluster machine must meet the following minimum requirements:

Table 5.27. Minimum resource requirements

Machine	Operating System	vCPU [1]	Virtual RAM	Storage	IOPS [2]
Bootstrap	RHCOS	4	16 GB	100 GB	300
Control plane	RHCOS	4	16 GB	100 GB	300
Compute	RHCOS, RHEL 8.6 and later [3]	2	8 GB	100 GB	300

1. One vCPU is equivalent to one physical core when simultaneous multithreading (SMT), or hyperthreading, is not enabled. When enabled, use the following formula to calculate the corresponding ratio: (threads per core × cores) × sockets = vCPUs.

2. OpenShift Container Platform and Kubernetes are sensitive to disk performance, and faster storage is recommended, particularly for etcd on the control plane nodes which require a 10 ms p99 fsync duration. Note that on many cloud platforms, storage size and IOPS scale together, so you might need to over-allocate storage volume to obtain sufficient performance.

3. As with all user-provisioned installations, if you choose to use RHEL compute machines in your cluster, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks.

Use of RHEL 7 compute machines is deprecated and has been removed in OpenShift Container Platform 4.10 and later.

If an instance type for your platform meets the minimum requirements for cluster machines, it is supported to use in OpenShift Container Platform.

Additional resources

- Optimizing storage

5.8.6.3. Tested instance types for AWS

The following Amazon Web Services (AWS) instance types have been tested with OpenShift Container Platform.

NOTE

Use the machine types included in the following charts for your AWS instances. If you use an instance type that is not listed in the chart, ensure that the instance size you use matches the minimum resource requirements that are listed in "Minimum resource requirements for cluster installation".

Example 5.20. Machine types based on 64-bit x86 architecture

- **c4.***
- **c5.***
- **c5a.***
- **i3.***
- **m4.***
- **m5.***
- **m5a.***
- **m6a.***
- **m6i.***
- **r4.***
- **r5.***
- **r5a.***
- **r6i.***
- **t3.***
- **t3a.***

5.8.6.4. Tested instance types for AWS on 64-bit ARM infrastructures

The following Amazon Web Services (AWS) ARM64 instance types have been tested with OpenShift Container Platform.

NOTE

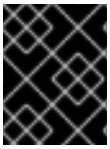
Use the machine types included in the following charts for your AWS ARM instances. If you use an instance type that is not listed in the chart, ensure that the instance size you use matches the minimum resource requirements that are listed in "Minimum resource requirements for cluster installation".

Example 5.21. Machine types based on 64-bit ARM architecture

- **c6g.***
- **m6g.***

5.8.6.5. Sample customized install-config.yaml file for AWS

You can customize the installation configuration file (**install-config.yaml**) to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.



IMPORTANT

This sample YAML file is provided for reference only. You must obtain your **install-config.yaml** file by using the installation program and modify it.

```
apiVersion: v1
baseDomain: example.com (1)
credentialsMode: Mint (2)
controlPlane: (3) (4)
  hyperthreading: Enabled (5)
  name: master
  platform:
    aws:
      zones:
      - us-west-2a
      - us-west-2b
      rootVolume:
        iops: 4000
        size: 500
        type: io1 (6)
      metadataService:
        authentication: Optional (7)
      type: m6i.xlarge
  replicas: 3
compute: (8)
- hyperthreading: Enabled (9)
  name: worker
  platform:
    aws:
```

```
      rootVolume:
        iops: 2000
        size: 500
        type: io1 10
      metadataService:
        authentication: Optional 11
      type: c5.4xlarge
      zones:
      - us-west-2c
  replicas: 3
metadata:
  name: test-cluster 12
networking:
  clusterNetwork:
  - cidr: 10.128.0.0/14
    hostPrefix: 23
  machineNetwork:
  - cidr: 10.0.0.0/16
  networkType: OpenShiftSDN
  serviceNetwork:
  - 172.30.0.0/16
platform:
  aws:
    region: us-west-2 13
    userTags:
      adminContact: jdoe
      costCenter: 7536
    subnets: 14
    - subnet-1
    - subnet-2
    - subnet-3
    amiID: ami-96c6f8f7 15
    serviceEndpoints: 16
      - name: ec2
        url: https://vpce-id.ec2.us-west-2.vpce.amazonaws.com
    hostedZone: Z3URY6TWQ91KVV 17
fips: false 18
sshKey: ssh-ed25519 AAAA... 19
pullSecret: '{"auths": ...}' 20
```

1 12 13 20 Required. The installation program prompts you for this value.

2 Optional: Add this parameter to force the Cloud Credential Operator (CCO) to use the specified mode, instead of having the CCO dynamically try to determine the capabilities of the credentials. For details about CCO modes, see the *Cloud Credential Operator* entry in the *Red Hat Operators reference* content.

3 8 If you do not provide these parameters and values, the installation program provides the default value.

4 The **controlPlane** section is a single mapping, but the **compute** section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, **-**, and the first line of the **controlPlane** section must not. Only one control plane pool is used.

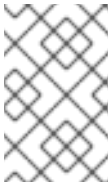
5 9 Whether to enable or disable simultaneous multithreading, or **hyperthreading**. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores. You

IMPORTANT

If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance. Use larger instance types, such as **m4.2xlarge** or **m5.2xlarge**, for your machines if you disable simultaneous multithreading.

6 10 To configure faster storage for etcd, especially for larger clusters, set the storage type as **io1** and set **iops** to **2000**.

7 11 Whether to require the Amazon EC2 Instance Metadata Service v2 (IMDSv2). To require IMDSv2, set the parameter value to **Required**. To allow the use of both IMDSv1 and IMDSv2, set the parameter value to **Optional**. If no value is specified, both IMDSv1 and IMDSv2 are allowed.



NOTE

The IMDS configuration for control plane machines that is set during cluster installation can only be changed by using the AWS CLI. The IMDS configuration for compute machines can be changed by using machine sets.

14 If you provide your own VPC, specify subnets for each availability zone that your cluster uses.

15 The ID of the AMI used to boot machines for the cluster. If set, the AMI must belong to the same region as the cluster.

16 The AWS service endpoints. Custom endpoints are required when installing to an unknown AWS region. The endpoint URL must use the **https** protocol and the host must trust the certificate.

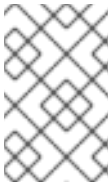
17 The ID of your existing Route 53 private hosted zone. Providing an existing hosted zone requires that you supply your own VPC and the hosted zone is already associated with the VPC prior to installing your cluster. If undefined, the installation program creates a new hosted zone.

18 Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.

IMPORTANT

To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.

19 You can optionally provide the **sshKey** value that you use to access the machines in your cluster.



NOTE

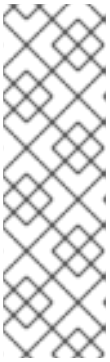
For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

5.8.6.6. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.



NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: ec2.<region>.amazonaws.com,elasticloadbalancing.
<region>.amazonaws.com,s3.<region>.amazonaws.com 3
additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
```

1. A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
2. A proxy URL to use for creating HTTPS connections outside the cluster.

3 A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For

4 If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace that contains one or more additional CA certificates that are required for proxying HTTPS connections. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges these contents with the Red Hat Enterprise Linux CoreOS (RHCOS) trust bundle, and this config map is referenced in the **trustedCA** field of the **Proxy** object. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.

NOTE

The installation program does not support the proxy **readinessEndpoints** field.

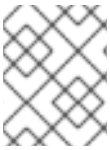
NOTE

If the installer times out, restart and then complete the deployment by using the **wait-for** command of the installer. For example:

```
$ ./openshift-install wait-for install-complete --log-level debug
```

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.



NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

5.8.7. Deploying the cluster

You can install OpenShift Container Platform on a compatible cloud platform.

IMPORTANT

You can run the **create cluster** command of the installation program only once, during initial installation.

Prerequisites

- Configure an account with the cloud platform that hosts your cluster.
- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.

Procedure

1. Change to the directory that contains the installation program and initialize the cluster deployment:

```
$ ./openshift-install create cluster --dir <installation_directory> \ 1
    --log-level=info 2
```

1 For **<installation_directory>**, specify the location of your customized **./install-config.yaml** file.

2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

NOTE

If the cloud provider account that you configured on your host does not have sufficient permissions to deploy the cluster, the installation process stops, and the missing permissions are displayed.

2. Optional: Remove or disable the **AdministratorAccess** policy from the IAM account that you used to install the cluster.

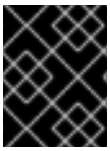
NOTE

The elevated permissions provided by the **AdministratorAccess** policy are required only during installation.

Verification

When the cluster deployment completes successfully:

- The terminal displays directions for accessing your cluster, including a link to the web console and credentials for the **kubeadmin** user.
- Credential information also outputs to **<installation_directory>/.openshift_install.log**.



IMPORTANT

Do not delete the installation program or the files that the installation program creates. Both are required to delete the cluster.

Example output

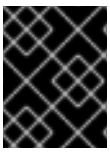
```
...
INFO Install complete!
INFO To access the cluster as the system:admin user when using 'oc', run 'export
KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
INFO Access the OpenShift web-console here: https://console-openshift-
console.apps.mycluster.example.com
INFO Login to the console with user: "kubeadmin", and password: "password"
INFO Time elapsed: 36m22s
```

IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

5.8.8. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.



IMPORTANT

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.11. Download and install the new version of **oc**.

Installing the OpenShift CLI on Linux

You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the architecture in the **Product Variant** drop-down menu.
3. Select the appropriate version in the **Version** drop-down menu.
4. Click **Download Now** next to the **OpenShift v4.11 Linux Client** entry and save the file.
5. Unpack the archive:

```
$ tar xvf <file>
```

6. Place the **oc** binary in a directory that is on your **PATH**.
   To check your **PATH**, execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

-

Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.
   To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
C:\> oc <command>
```

Installing the OpenShift CLI on macOS

You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 macOS Client** entry and save the file.

NOTE

For macOS arm64, choose the **OpenShift v4.11 macOS arm64 Client** entry.

4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your PATH.
   To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

5.8.9. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

Example output

```
system:admin
```

5.8.10. Logging in to the cluster by using the web console

The **kubeadmin** user exists by default after an OpenShift Container Platform installation. You can log in to your cluster as the **kubeadmin** user by using the OpenShift Container Platform web console.

Prerequisites

- You have access to the installation host.
- You completed a cluster installation and all cluster Operators are available.

Procedure

1. Obtain the password for the **kubeadmin** user from the **kubeadmin-password** file on the installation host:

```
$ cat <installation_directory>/auth/kubeadmin-password
```

NOTE

Alternatively, you can obtain the **kubeadmin** password from the **<installation_directory>/.openshift_install.log** log file on the installation host.

2. List the OpenShift Container Platform web console route:

```
$ oc get routes -n openshift-console | grep 'console-openshift'
```

NOTE

Alternatively, you can obtain the OpenShift Container Platform route from the **<installation_directory>/.openshift_install.log** log file on the installation host.

Example output

```
console     console-openshift-console.apps.<cluster_name>.<base_domain>           console
https   reencrypt/Redirect   None
```

3. Navigate to the route detailed in the output of the preceding command in a web browser and log in as the **kubeadmin** user.

Additional resources

- See Accessing the web console for more details about accessing and understanding the OpenShift Container Platform web console.

5.8.11. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.11, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to OpenShift Cluster Manager Hybrid Cloud Console.

After you confirm that your OpenShift Cluster Manager Hybrid Cloud Console inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, use subscription watch to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

Additional resources

- See About remote health monitoring for more information about the Telemetry service.

5.8.12. Next steps

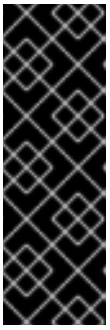
- Validating an installation.
- Customize your cluster.
- If necessary, you can opt out of remote health reporting .
- If necessary, you can remove cloud provider credentials.

5.9. INSTALLING A PRIVATE CLUSTER ON AWS

In OpenShift Container Platform version 4.11, you can install a private cluster into an existing VPC on Amazon Web Services (AWS). The installation program provisions the rest of the required infrastructure, which you can further customize. To customize the installation, you modify parameters in the **install-config.yaml** file before you install the cluster.

5.9.1. Prerequisites

- You reviewed details about the OpenShift Container Platform installation and update processes.
- You read the documentation on selecting a cluster installation method and preparing it for users.
- You configured an AWS account to host the cluster.



IMPORTANT

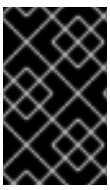
If you have an AWS profile stored on your computer, it must not use a temporary session token that you generated while using a multi-factor authentication device. The cluster continues to use your current AWS credentials to create AWS resources for the entire life of the cluster, so you must use long-lived credentials. To generate appropriate keys, see Managing Access Keys for IAM Users in the AWS documentation. You can supply the keys when you run the installation program.

- If you use a firewall, you configured it to allow the sites that your cluster requires access to.
- If the cloud identity and access management (IAM) APIs are not accessible in your environment, or if you do not want to store an administrator-level credential secret in the **kube-system** namespace, you can manually create and maintain IAM credentials.

5.9.2. Private clusters

You can deploy a private OpenShift Container Platform cluster that does not expose external endpoints. Private clusters are accessible from only an internal network and are not visible to the internet.

By default, OpenShift Container Platform is provisioned to use publicly-accessible DNS and endpoints. A private cluster sets the DNS, Ingress Controller, and API server to private when you deploy your cluster. This means that the cluster resources are only accessible from your internal network and are not visible to the internet.



IMPORTANT

If the cluster has any public subnets, load balancer services created by administrators might be publicly accessible. To ensure cluster security, verify that these services are explicitly annotated as private.

To deploy a private cluster, you must:

- Use existing networking that meets your requirements. Your cluster resources might be shared between other clusters on the network.

- Deploy from a machine that has access to:
  - The API services for the cloud to which you provision.
  - The hosts on the network that you provision.
  - The internet to obtain installation media.

You can use any machine that meets these access requirements and follows your company's guidelines. For example, this machine can be a bastion host on your cloud network or a machine that has access to the network through a VPN.

5.9.2.1. Private clusters in AWS

To create a private cluster on Amazon Web Services (AWS), you must provide an existing private VPC and subnets to host the cluster. The installation program must also be able to resolve the DNS records that the cluster requires. The installation program configures the Ingress Operator and API server for access from only the private network.

The cluster still requires access to internet to access the AWS APIs.

The following items are not required or created when you install a private cluster:

- Public subnets
- Public load balancers, which support public ingress
- A public Route 53 zone that matches the **baseDomain** for the cluster

The installation program does use the **baseDomain** that you specify to create a private Route 53 zone and the required records for the cluster. The cluster is configured so that the Operators do not create public records for the cluster and all cluster machines are placed in the private subnets that you specify.

5.9.2.1.1. Limitations

The ability to add public functionality to a private cluster is limited.

- You cannot make the Kubernetes API endpoints public after installation without taking additional actions, including creating public subnets in the VPC for each availability zone in use, creating a public load balancer, and configuring the control plane security groups to allow traffic from the internet on 6443 (Kubernetes API port).
- If you use a public Service type load balancer, you must tag a public subnet in each availability zone with **kubernetes.io/cluster/<cluster-infra-id>: shared** so that AWS can use them to create public load balancers.

5.9.3. About using a custom VPC

In OpenShift Container Platform 4.11, you can deploy a cluster into existing subnets in an existing Amazon Virtual Private Cloud (VPC) in Amazon Web Services (AWS). By deploying OpenShift Container Platform into an existing AWS VPC, you might be able to avoid limit constraints in new accounts or more easily abide by the operational constraints that your company's guidelines set. If you cannot obtain the infrastructure creation permissions that are required to create the VPC yourself, use this installation option.

Because the installation program cannot know what other components are also in your existing subnets, it cannot choose subnet CIDRs and so forth on your behalf. You must configure networking for the subnets that you install your cluster to yourself.

5.9.3.1. Requirements for using your VPC

The installation program no longer creates the following components:

- Internet gateways
- NAT gateways
- Subnets
- Route tables
- VPCs
- VPC DHCP options
- VPC endpoints

NOTE

The installation program requires that you use the cloud-provided DNS server. Using a custom DNS server is not supported and causes the installation to fail.

If you use a custom VPC, you must correctly configure it and its subnets for the installation program and the cluster to use. See Amazon VPC console wizard configurations and Work with VPCs and subnets in the AWS documentation for more information on creating and managing an AWS VPC.

The installation program cannot:

- Subdivide network ranges for the cluster to use.
- Set route tables for the subnets.
- Set VPC options like DHCP.

You must complete these tasks before you install the cluster. See VPC networking components and Route tables for your VPC for more information on configuring networking in an AWS VPC.

Your VPC must meet the following characteristics:

- The VPC must not use the **kubernetes.io/cluster/.*: owned**, **Name**, and **openshift.io/cluster** tags.
  The installation program modifies your subnets to add the **kubernetes.io/cluster/.*: shared** tag, so your subnets must have at least one free tag slot available for it. See Tag Restrictions in the AWS documentation to confirm that the installation program can add a tag to each subnet that you specify. You cannot use a **Name** tag, because it overlaps with the EC2 **Name** field and the installation fails.
- You must enable the **enableDnsSupport** and **enableDnsHostnames** attributes in your VPC, so that the cluster can use the Route 53 zones that are attached to the VPC to resolve cluster's internal DNS records. See DNS Support in Your VPC in the AWS documentation.

If you prefer to use your own Route 53 hosted private zone, you must associate the existing hosted zone with your VPC prior to installing a cluster. You can define your hosted zone using the **platform.aws.hostedZone** field in the **install-config.yaml** file.

If you are working in a disconnected environment, you are unable to reach the public IP addresses for EC2, ELB, and S3 endpoints. Depending on the level to which you want to restrict internet traffic during the installation, the following configuration options are available:

Option 1: Create VPC endpoints
Create a VPC endpoint and attach it to the subnets that the clusters are using. Name the endpoints as follows:

- **ec2.<region>.amazonaws.com**
- **elasticloadbalancing.<region>.amazonaws.com**
- **s3.<region>.amazonaws.com**

With this option, network traffic remains private between your VPC and the required AWS services.

Option 2: Create a proxy without VPC endpoints
As part of the installation process, you can configure an HTTP or HTTPS proxy. With this option, internet traffic goes through the proxy to reach the required AWS services.

Option 3: Create a proxy with VPC endpoints
As part of the installation process, you can configure an HTTP or HTTPS proxy with VPC endpoints. Create a VPC endpoint and attach it to the subnets that the clusters are using. Name the endpoints as follows:

- **ec2.<region>.amazonaws.com**
- **elasticloadbalancing.<region>.amazonaws.com**
- **s3.<region>.amazonaws.com**

When configuring the proxy in the **install-config.yaml** file, add these endpoints to the **noProxy** field. With this option, the proxy prevents the cluster from accessing the internet directly. However, network traffic remains private between your VPC and the required AWS services.

Required VPC components

You must provide a suitable VPC and subnets that allow communication to your machines.

Component	AWS type	Description
VPC	• **AWS::EC2::VPC** • **AWS::EC2::VPCEndpoint**	You must provide a public VPC for the cluster to use. The VPC uses an endpoint that references the route tables for each subnet to improve communication with the registry that is hosted in S3.

<table>
<tr><th>Component</th><th>AWS type</th><th>Description</th></tr>
<tr><td>Public subnets</td><td>AWS::EC2::Subnet
AWS::EC2::SubnetNetworkAclAssociation</td><td>Your VPC must have public subnets for between 1 and 3 availability zones and associate them with appropriate Ingress rules.</td></tr>
<tr><td>Internet gateway</td><td>AWS::EC2::InternetGateway
AWS::EC2::VPCGatewayAttachment
AWS::EC2::RouteTable
AWS::EC2::Route
AWS::EC2::SubnetRouteTableAssociation
AWS::EC2::NatGateway
AWS::EC2::EIP</td><td>You must have a public internet gateway, with public routes, attached to the VPC. In the provided templates, each public subnet has a NAT gateway with an EIP address. These NAT gateways allow cluster resources, like private subnet instances, to reach the internet and are not required for some restricted network or proxy scenarios.</td></tr>
<tr><td>Network access control</td><td>AWS::EC2::NetworkAcl
AWS::EC2::NetworkAclEntry</td><td>You must allow the VPC to access the following ports:<table><tr><th>Port</th><th>Reason</th></tr><tr><td>80</td><td>Inbound HTTP traffic</td></tr><tr><td>443</td><td>Inbound HTTPS traffic</td></tr><tr><td>22</td><td>Inbound SSH traffic</td></tr><tr><td>1024 - 65535</td><td>Inbound ephemeral traffic</td></tr><tr><td>0 - 65535</td><td>Outbound ephemeral traffic</td></tr></table></td></tr>
<tr><td>Private subnets</td><td>AWS::EC2::Subnet
AWS::EC2::RouteTable
AWS::EC2::SubnetRouteTableAssociation</td><td>Your VPC can have private subnets. The provided CloudFormation templates can create private subnets for between 1 and 3 availability zones. If you use private subnets, you must provide appropriate routes and tables for them.</td></tr>
</table>

5.9.3.2. VPC validation

To ensure that the subnets that you provide are suitable, the installation program confirms the following data:

- All the subnets that you specify exist.
- You provide private subnets.
- The subnet CIDRs belong to the machine CIDR that you specified.
- You provide subnets for each availability zone. Each availability zone contains no more than one public and one private subnet. If you use a private cluster, provide only a private subnet for each availability zone. Otherwise, provide exactly one public and private subnet for each availability zone.
- You provide a public subnet for each private subnet availability zone. Machines are not provisioned in availability zones that you do not provide private subnets for.

If you destroy a cluster that uses an existing VPC, the VPC is not deleted. When you remove the OpenShift Container Platform cluster from a VPC, the **kubernetes.io/cluster/.*: shared** tag is removed from the subnets that it used.

5.9.3.3. Division of permissions

Starting with OpenShift Container Platform 4.3, you do not need all of the permissions that are required for an installation program-provisioned infrastructure cluster to deploy a cluster. This change mimics the division of permissions that you might have at your company: some individuals can create different resource in your clouds than others. For example, you might be able to create application-specific items, like instances, buckets, and load balancers, but not networking-related components such as VPCs, subnets, or ingress rules.

The AWS credentials that you use when you create your cluster do not need the networking permissions that are required to make VPCs and core networking components within the VPC, such as subnets, routing tables, internet gateways, NAT, and VPN. You still need permission to make the application resources that the machines within the cluster require, such as ELBs, security groups, S3 buckets, and nodes.

5.9.3.4. Isolation between clusters

If you deploy OpenShift Container Platform to an existing network, the isolation of cluster services is reduced in the following ways:

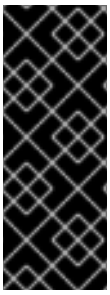
- You can install multiple OpenShift Container Platform clusters in the same VPC.
- ICMP ingress is allowed from the entire network.
- TCP 22 ingress (SSH) is allowed to the entire network.
- Control plane TCP 6443 ingress (Kubernetes API) is allowed to the entire network.
- Control plane TCP 22623 ingress (MCS) is allowed to the entire network.

5.9.4. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.11, you require access to the internet to install your cluster.

You must have internet access to:

- Access OpenShift Cluster Manager Hybrid Cloud Console to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access Quay.io to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.



IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

5.9.5. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the **~/.ssh/authorized_keys** list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The **./openshift-install gather** command also requires the SSH public key to be in place on the cluster nodes.

IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.

NOTE

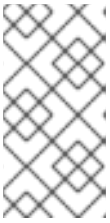
You must use a local key, not one that you configured with platform-specific approaches such as AWS key pairs.

Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N '' -f <path>/<file_name>
```
(1)

1 Specify the path and file name, such as ~/**.ssh/id_ed25519**, of the new SSH key. If you have an existing key pair, ensure your public key is in the your ~/**.ssh** directory.



NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS validated or Modules In Process cryptographic libraries on the **x86_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the ~/**.ssh/id_ed25519.pub** public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the **./openshift-install gather** command.

NOTE

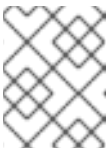
On some distributions, default SSH private key identities such as ~/**.ssh/id_rsa** and ~/**.ssh/id_dsa** are managed automatically.

a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

Example output

```
Agent pid 31874
```



NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

1 Specify the path and file name for your SSH private key, such as ~/**.ssh/id_ed25519**

Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

5.9.6. Obtaining the installation program

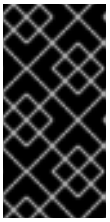
Before you install OpenShift Container Platform, download the installation file on a local computer.

Prerequisites

- You have a computer that runs Linux or macOS, with 500 MB of local disk space.

Procedure

1. Access the Infrastructure Provider page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program that corresponds with your host operating system and architecture, and place the file in the directory where you will store the installation configuration files.



IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.

IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation pull secret from the Red Hat OpenShift Cluster Manager . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

5.9.7. Manually creating the installation configuration file

For installations of a private OpenShift Container Platform cluster that are only accessible from an internal network and are not visible to the internet, you must manually generate your installation configuration file.

Prerequisites

- You have an SSH public key on your local machine to provide to the installation program. The key will be used for SSH authentication onto your cluster nodes for debugging and disaster recovery.
- You have obtained the OpenShift Container Platform installation program and the pull secret for your cluster.

Procedure

1. Create an installation directory to store your required installation assets in:

```
$ mkdir <installation_directory>
```

IMPORTANT

You must create a directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

2. Customize the sample **install-config.yaml** file template that is provided and save it in the **<installation_directory>**.

NOTE

You must name this configuration file **install-config.yaml**.

NOTE

For some platform types, you can alternatively run **./openshift-install create install-config --dir <installation_directory>** to generate an **install-config.yaml** file. You can provide details about your cluster configuration at the prompts.

3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.

IMPORTANT

The **install-config.yaml** file is consumed during the next step of the installation process. You must back it up now.

5.9.7.1. Installation configuration parameters

Before you deploy an OpenShift Container Platform cluster, you provide parameter values to describe your account on the cloud platform that hosts your cluster and optionally customize your cluster's platform. When you create the **install-config.yaml** installation configuration file, you provide values for

the required parameters through the command line. If you customize your cluster, you can modify the **install-config.yaml** file to provide more details about the platform.

NOTE

After installation, you cannot modify these parameters in the **install-config.yaml** file.

5.9.7.1.1. Required configuration parameters

Required installation configuration parameters are described in the following table:

Table 5.28. Required parameters

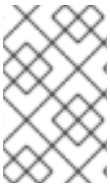
Parameter	Description	Values
apiVersion	The API version for the **install-config.yaml** content. The current version is **v1**. The installer may also support older API versions.	String
baseDomain	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the **baseDomain** and **metadata.name** parameter values that uses the **<metadata.name>.<baseDomain>** format.	A fully-qualified domain or subdomain name, such as **example.com**.
metadata	Kubernetes resource **ObjectMeta**, from which only the **name** parameter is consumed.	Object
metadata.name	The name of the cluster. DNS records for the cluster are all subdomains of **{{.metadata.name}}.{{.baseDomain}}**.	String of lowercase letters, hyphens (**-**), and periods (**.**), such as **dev**.

Parameter	Description	Values
platform	The configuration for the specific platform upon which to perform the installation: **alibabacloud**, **aws**, **baremetal**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**. For additional information about **platform.<platform>** parameters, consult the table for your specific platform that follows.	Object
pullSecret	Get a pull secret from the Red Hat OpenShift Cluster Manager to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	<pre>{ "auths":{ "cloud.openshift.com":{ "auth":"b3Blb=", "email":"you@example.com" }, "quay.io":{ "auth":"b3Blb=", "email":"you@example.com" } } }</pre>

5.9.7.1.2. Network configuration parameters

You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

Only IPv4 addresses are supported.



NOTE

Globalnet is not supported with Red Hat OpenShift Data Foundation disaster recovery solutions. For regional disaster recovery scenarios, ensure that you use a nonoverlapping range of private IP addresses for the cluster and service networks in each cluster.

Table 5.29. Network parameters

Parameter	Description	Values

Parameter	Description	Values
networking	The configuration for the cluster network.	Object  **NOTE** You cannot modify parameters specified by the **networking** object after installation.
networking.networkType	The cluster network provider Container Network Interface (CNI) cluster network provider to install.	Either **OpenShiftSDN** or **OVNKubernetes**. **OpenShiftSDN** is a CNI provider for all-Linux networks. **OVNKubernetes** is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is **OpenShiftSDN**.
networking.clusterNetwork	The IP address blocks for pods. The default value is **10.128.0.0/14** with a host prefix of **/23**. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: `networking:` `  clusterNetwork:` `  - cidr: 10.128.0.0/14` `    hostPrefix: 23`
networking.clusterNetwork.cidr	Required if you use **networking.clusterNetwork**. An IP address block. An IPv4 network.	An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between **0** and **32**.
networking.clusterNetwork.hostPrefix	The subnet prefix length to assign to each individual node. For example, if **hostPrefix** is set to **23** then each node is assigned a **/23** subnet out of the given **cidr**. A **hostPrefix** value of **23** provides 510 (2^(32 - 23) - 2) pod IP addresses.	A subnet prefix. The default value is **23**.
networking.serviceNetwork	The IP address block for services. The default value is **172.30.0.0/16**. The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.	An array with an IP address block in CIDR format. For example: `networking:` `  serviceNetwork:` `  - 172.30.0.0/16`

Parameter	Description	Values
networking.machineNetwork	The IP address blocks for machines. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: `networking:` `  machineNetwork:` `  - cidr: 10.0.0.0/16`
networking.machineNetwork.cidr	Required if you use **networking.machineNetwork**. An IP address block. The default value is **10.0.0.0/16** for all platforms other than libvirt. For libvirt, the default value is **192.168.126.0/24**.	An IP network block in CIDR notation. For example, **10.0.0.0/16**. **NOTE** Set the **networking.machineNetwork** to match the CIDR that the preferred NIC resides in.

5.9.7.1.3. Optional configuration parameters

Optional installation configuration parameters are described in the following table:

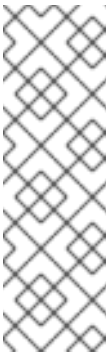
Table 5.30. Optional parameters

Parameter	Description	Values
additionalTrustBundle	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String
capabilities	Controls the installation of optional core cluster components. You can reduce the footprint of your OpenShift Container Platform cluster by disabling optional components.	String array

Parameter	Description	Values
capabilities.baselineCapabilitySet	Selects an initial set of optional capabilities to enable. Valid values are **None**, **v4.11** and **vCurrent**. **v4.11** enables the **baremetal** Operator, the **marketplace** Operator, and the **openshift-samples** content. **vCurrent** installs the recommended set of capabilities for the current version of OpenShift Container Platform. The default value is **vCurrent**.	String
capabilities.additionalEnabledCapabilities	Extends the set of optional capabilities beyond what you specify in **baselineCapabilitySet**. Valid values are **baremetal**, **marketplace** and **openshift-samples**. You may specify multiple capabilities in this parameter.	String array
cgroupsV2	Enables Linux control groups version 2 (cgroups v2) on specific nodes in your cluster. The OpenShift Container Platform process for enabling cgroups v2 disables all cgroup version 1 controllers and hierarchies. The OpenShift Container Platform cgroups version 2 feature is in Developer Preview and is not supported by Red Hat at this time.	**true**
compute	The configuration for the machines that comprise the compute nodes.	Array of **MachinePool** objects.
compute.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** and **arm64**. Not all installation options support the 64-bit ARM architecture. To verify if your installation option is supported on your platform, see *Supported installation methods for different platforms* in *Selecting a cluster installation method and preparing it for users*.	String

Parameter	Description	Values
compute.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  **IMPORTANT** If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
compute.name	Required if you use **compute**. The name of the machine pool.	**worker**
compute.platform	Required if you use **compute**. Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the **controlPlane.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
compute.replicas	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to **2**. The default value is **3**.
controlPlane	The configuration for the machines that comprise the control plane.	Array of **MachinePool** objects.
controlPlane.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** and **arm64**. Not all installation options support the 64-bit ARM architecture. To verify if your installation option is supported on your platform, see *Supported installation methods for different platforms* in *Selecting a cluster installation method and preparing it for users*.	String

Parameter	Description	Values
controlPlane.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  **IMPORTANT** If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
controlPlane.name	Required if you use **controlPlane**. The name of the machine pool.	**master**
controlPlane.platform	Required if you use **controlPlane**. Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the **compute.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
controlPlane.replicas	The number of control plane machines to provision.	The only supported value is **3**, which is the default value.

Parameter	Description	Values
credentialsMode	The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported.  **NOTE** Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the *Cloud Credential Operator* entry in the *Cluster Operators reference* content.  **NOTE** If your AWS account has service control policies (SCP) enabled, you must configure the **credentialsMode** parameter to **Mint**, **Passthrough** or **Manual**.	**Mint**, **Passthrough**, **Manual** or an empty string (**""**).

Parameter	Description	Values
fips	Enable or disable FIPS mode. The default is **false** (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.  **IMPORTANT** To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.  **NOTE** If you are using Azure File storage, you cannot enable FIPS mode.	**false** or **true**
imageContentSources	Sources and repositories for the release-image content.	Array of objects. Includes a **source** and, optionally, **mirrors**, as described in the following rows of this table.
imageContentSources.source	Required if you use **imageContentSources**. Specify the repository that users refer to, for example, in image pull specifications.	String

Parameter	Description	Values
imageContentSources.mirrors	Specify one or more repositories that may also contain the same images.	Array of strings
publish	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	**Internal** or **External**. To deploy a private cluster, which cannot be accessed from the internet, set **publish** to **Internal**. The default value is **External**.
sshKey	The SSH key to authenticate access to your cluster machines.  **NOTE** For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.	For example, **sshKey: ssh-ed25519 AAAA..**.

5.9.7.1.4. Optional AWS configuration parameters

Optional AWS configuration parameters are described in the following table:

Table 5.31. Optional AWS parameters

Parameter	Description	Values
compute.platform.aws.amiID	The AWS AMI used to boot compute machines for the cluster. This is required for regions that require a custom RHCOS AMI.	Any published or custom RHCOS AMI that belongs to the set AWS region. See *RHCOS AMIs for AWS infrastructure* for available AMI IDs.

Parameter	Description	Values
compute.platform.aws.iamRole	A pre-existing AWS IAM role applied to the compute machine pool instance profiles. You can use these fields to match naming schemes and include predefined permissions boundaries for your IAM roles. If undefined, the installation program creates a new IAM role.	The name of a valid AWS IAM role.
compute.platform.aws.rootVolume.iops	The Input/Output Operations Per Second (IOPS) that is reserved for the root volume.	Integer, for example **4000**.
compute.platform.aws.rootVolume.size	The size in GiB of the root volume.	Integer, for example **500**.
compute.platform.aws.rootVolume.type	The type of the root volume.	Valid AWS EBS volume type, such as **io1**.
compute.platform.aws.rootVolume.kmsKeyARN	The Amazon Resource Name (key ARN) of a KMS key. This is required to encrypt OS volumes of worker nodes with a specific KMS key.	Valid key ID or the key ARN
compute.platform.aws.type	The EC2 instance type for the compute machines.	Valid AWS instance type, such as **m4.2xlarge**. See the **Supported AWS machine types** table that follows.
compute.platform.aws.zones	The availability zones where the installation program creates machines for the compute machine pool. If you provide your own VPC, you must provide a subnet in that availability zone.	A list of valid AWS availability zones, such as **us-east-1c**, in a YAML sequence.

Parameter	Description	Values
compute.aws.region	The AWS region that the installation program creates compute resources in.	Any valid AWS region, such as **us-east-1**. You can use the AWS CLI to access the regions available based on your selected instance type. For example: `aws ec2 describe-instance-type-offerings --filters Name=instance-type,Values=c7g.xlarge`  **IMPORTANT** When running on ARM based AWS instances, ensure that you enter a region where AWS Graviton processors are available. See Global availability map in the AWS documentation. Currently, AWS Graviton3 processors are only available in some regions.
controlPlane.platform.aws.amiID	The AWS AMI used to boot control plane machines for the cluster. This is required for regions that require a custom RHCOS AMI.	Any published or custom RHCOS AMI that belongs to the set AWS region. See *RHCOS AMIs for AWS infrastructure* for available AMI IDs.
controlPlane.platform.aws.iamRole	A pre-existing AWS IAM role applied to the control plane machine pool instance profiles. You can use these fields to match naming schemes and include predefined permissions boundaries for your IAM roles. If undefined, the installation program creates a new IAM role.	The name of a valid AWS IAM role.
controlPlane.platform.aws.rootVolume.kmsKeyARN	The Amazon Resource Name (key ARN) of a KMS key. This is required to encrypt OS volumes of control plane nodes with a specific KMS key.	Valid key ID and the key ARN.
controlPlane.platform.aws.type	The EC2 instance type for the control plane machines.	Valid AWS instance type, such as **m6i.xlarge**. See the **Supported AWS machine types** table that follows.

Parameter	Description	Values
controlPlane.platform.aws.zones	The availability zones where the installation program creates machines for the control plane machine pool.	A list of valid AWS availability zones, such as **us-east-1c**, in a YAML sequence.
controlPlane.aws.region	The AWS region that the installation program creates control plane resources in.	Valid AWS region, such as **us-east-1**.
platform.aws.amiID	The AWS AMI used to boot all machines for the cluster. If set, the AMI must belong to the same region as the cluster. This is required for regions that require a custom RHCOS AMI.	Any published or custom RHCOS AMI that belongs to the set AWS region. See *RHCOS AMIs for AWS infrastructure* for available AMI IDs.
platform.aws.hostedZone	An existing Route 53 private hosted zone for the cluster. You can only use a pre-existing hosted zone when also supplying your own VPC. The hosted zone must already be associated with the user-provided VPC before installation. Also, the domain of the hosted zone must be the cluster domain or a parent of the cluster domain. If undefined, the installation program creates a new hosted zone.	String, for example **Z3URY6TWQ91KVV**.
platform.aws.serviceEndpoints.name	The AWS service endpoint name. Custom endpoints are only required for cases where alternative AWS endpoints, like FIPS, must be used. Custom API endpoints can be specified for EC2, S3, IAM, Elastic Load Balancing, Tagging, Route 53, and STS AWS services.	Valid AWS service endpoint name.
platform.aws.serviceEndpoints.url	The AWS service endpoint URL. The URL must use the **https** protocol and the host must trust the certificate.	Valid AWS service endpoint URL.

Parameter	Description	Values
platform.aws.userTags	A map of keys and values that the installation program adds as tags to all resources that it creates.	Any valid YAML map, such as key value pairs in the **<key>: <value>** format. For more information about AWS tags, see Tagging Your Amazon EC2 Resources in the AWS documentation.
platform.aws.subnets	If you provide the VPC instead of allowing the installation program to create the VPC for you, specify the subnet for the cluster to use. The subnet must be part of the same **machineNetwork[].cidr** ranges that you specify. For a standard cluster, specify a public and a private subnet for each availability zone. For a private cluster, specify a private subnet for each availability zone.	Valid subnet IDs.

5.9.7.2. Minimum resource requirements for cluster installation

Each cluster machine must meet the following minimum requirements:

Table 5.32. Minimum resource requirements

Machine	Operating System	vCPU [1]	Virtual RAM	Storage	IOPS [2]
Bootstrap	RHCOS	4	16 GB	100 GB	300
Control plane	RHCOS	4	16 GB	100 GB	300
Compute	RHCOS, RHEL 8.6 and later [3]	2	8 GB	100 GB	300

1. One vCPU is equivalent to one physical core when simultaneous multithreading (SMT), or hyperthreading, is not enabled. When enabled, use the following formula to calculate the corresponding ratio: (threads per core × cores) × sockets = vCPUs.

2. OpenShift Container Platform and Kubernetes are sensitive to disk performance, and faster storage is recommended, particularly for etcd on the control plane nodes which require a 10 ms p99 fsync duration. Note that on many cloud platforms, storage size and IOPS scale together, so you might need to over-allocate storage volume to obtain sufficient performance.

3. As with all user-provisioned installations, if you choose to use RHEL compute machines in your cluster, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks.

Use of RHEL 7 compute machines is deprecated and has been removed in OpenShift Container Platform 4.10 and later.

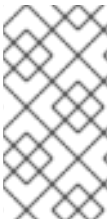
If an instance type for your platform meets the minimum requirements for cluster machines, it is supported to use in OpenShift Container Platform.

Additional resources

- Optimizing storage

5.9.7.3. Tested instance types for AWS

The following Amazon Web Services (AWS) instance types have been tested with OpenShift Container Platform.



NOTE

Use the machine types included in the following charts for your AWS instances. If you use an instance type that is not listed in the chart, ensure that the instance size you use matches the minimum resource requirements that are listed in "Minimum resource requirements for cluster installation".

Example 5.22. Machine types based on 64-bit x86 architecture

- **c4.***
- **c5.***
- **c5a.***
- **i3.***
- **m4.***
- **m5.***
- **m5a.***
- **m6a.***
- **m6i.***
- **r4.***
- **r5.***
- **r5a.***
- **r6i.***
- **t3.***
- **t3a.***

5.9.7.4. Tested instance types for AWS on 64-bit ARM infrastructures

The following Amazon Web Services (AWS) ARM64 instance types have been tested with OpenShift Container Platform.

NOTE

Use the machine types included in the following charts for your AWS ARM instances. If you use an instance type that is not listed in the chart, ensure that the instance size you use matches the minimum resource requirements that are listed in "Minimum resource requirements for cluster installation".

Example 5.23. Machine types based on 64-bit ARM architecture

- **c6g.***
- **m6g.***

5.9.7.5. Sample customized install-config.yaml file for AWS

You can customize the installation configuration file (**install-config.yaml**) to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.

IMPORTANT

This sample YAML file is provided for reference only. You must obtain your **install-config.yaml** file by using the installation program and modify it.

```
apiVersion: v1
baseDomain: example.com (1)
credentialsMode: Mint (2)
controlPlane: (3) (4)
  hyperthreading: Enabled (5)
  name: master
  platform:
    aws:
      zones:
      - us-west-2a
      - us-west-2b
      rootVolume:
        iops: 4000
        size: 500
        type: io1 (6)
      metadataService:
        authentication: Optional (7)
      type: m6i.xlarge
  replicas: 3
compute: (8)
- hyperthreading: Enabled (9)
  name: worker
  platform:
    aws:
```

```
      rootVolume:
        iops: 2000
        size: 500
        type: io1 10
      metadataService:
        authentication: Optional 11
      type: c5.4xlarge
      zones:
      - us-west-2c
  replicas: 3
metadata:
  name: test-cluster 12
networking:
  clusterNetwork:
  - cidr: 10.128.0.0/14
    hostPrefix: 23
  machineNetwork:
  - cidr: 10.0.0.0/16
  networkType: OpenShiftSDN
  serviceNetwork:
  - 172.30.0.0/16
platform:
  aws:
    region: us-west-2 13
    userTags:
      adminContact: jdoe
      costCenter: 7536
    subnets: 14
    - subnet-1
    - subnet-2
    - subnet-3
    amiID: ami-96c6f8f7 15
    serviceEndpoints: 16
      - name: ec2
        url: https://vpce-id.ec2.us-west-2.vpce.amazonaws.com
    hostedZone: Z3URY6TWQ91KVV 17
fips: false 18
sshKey: ssh-ed25519 AAAA... 19
publish: Internal 20
pullSecret: '{"auths": ...}' 21
```

1 12 13 21 Required. The installation program prompts you for this value.

2 Optional: Add this parameter to force the Cloud Credential Operator (CCO) to use the specified mode, instead of having the CCO dynamically try to determine the capabilities of the credentials. For details about CCO modes, see the *Cloud Credential Operator* entry in the *Red Hat Operators reference* content.

3 8 If you do not provide these parameters and values, the installation program provides the default value.

4 The **controlPlane** section is a single mapping, but the **compute** section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, **-**, and the first line of the **controlPlane** section must not. Only one control plane pool is used.

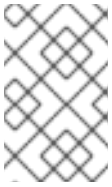
5 9 Whether to enable or disable simultaneous multithreading, or **hyperthreading**. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores. You

IMPORTANT

If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance. Use larger instance types, such as **m4.2xlarge** or **m5.2xlarge**, for your machines if you disable simultaneous multithreading.

6 10 To configure faster storage for etcd, especially for larger clusters, set the storage type as **io1** and set **iops** to **2000**.

7 11 Whether to require the Amazon EC2 Instance Metadata Service v2 (IMDSv2). To require IMDSv2, set the parameter value to **Required**. To allow the use of both IMDSv1 and IMDSv2, set the parameter value to **Optional**. If no value is specified, both IMDSv1 and IMDSv2 are allowed.



NOTE

The IMDS configuration for control plane machines that is set during cluster installation can only be changed by using the AWS CLI. The IMDS configuration for compute machines can be changed by using machine sets.

14 If you provide your own VPC, specify subnets for each availability zone that your cluster uses.

15 The ID of the AMI used to boot machines for the cluster. If set, the AMI must belong to the same region as the cluster.

16 The AWS service endpoints. Custom endpoints are required when installing to an unknown AWS region. The endpoint URL must use the **https** protocol and the host must trust the certificate.

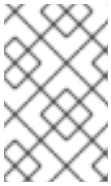
17 The ID of your existing Route 53 private hosted zone. Providing an existing hosted zone requires that you supply your own VPC and the hosted zone is already associated with the VPC prior to installing your cluster. If undefined, the installation program creates a new hosted zone.

18 Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.

IMPORTANT

To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.

19 You can optionally provide the **sshKey** value that you use to access the machines in your cluster.



NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

20 How to publish the user-facing endpoints of your cluster. Set **publish** to **Internal** to deploy a private cluster, which cannot be accessed from the internet. The default value is **External**.

5.9.7.6. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.

NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: ec2.<region>.amazonaws.com,elasticloadbalancing.
<region>.amazonaws.com,s3.<region>.amazonaws.com 3
additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
```

1 A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.

2 A proxy URL to use for creating HTTPS connections outside the cluster.

3 A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use ***** to bypass the proxy for all destinations. If you have added the Amazon **EC2**,**Elastic Load Balancing**, and **S3** VPC endpoints to your VPC, you must add these endpoints to the **noProxy** field.

4 If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace that contains one or more additional CA certificates that are required for proxying HTTPS connections. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges these contents with the Red Hat Enterprise Linux CoreOS (RHCOS) trust bundle, and this config map is referenced in the **trustedCA** field of the **Proxy** object. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.

NOTE

The installation program does not support the proxy **readinessEndpoints** field.

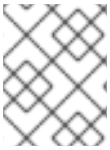
NOTE

If the installer times out, restart and then complete the deployment by using the **wait-for** command of the installer. For example:

```
$ ./openshift-install wait-for install-complete --log-level debug
```

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.



NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

5.9.8. Deploying the cluster

You can install OpenShift Container Platform on a compatible cloud platform.

IMPORTANT

You can run the **create cluster** command of the installation program only once, during initial installation.

Prerequisites

- Configure an account with the cloud platform that hosts your cluster.

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.

Procedure

1. Change to the directory that contains the installation program and initialize the cluster deployment:

```
$ ./openshift-install create cluster --dir <installation_directory> \ 1
    --log-level=info 2
```

1 For **<installation_directory>**, specify the location of your customized **./install-config.yaml** file.

2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

NOTE

If the cloud provider account that you configured on your host does not have sufficient permissions to deploy the cluster, the installation process stops, and the missing permissions are displayed.

2. Optional: Remove or disable the **AdministratorAccess** policy from the IAM account that you used to install the cluster.

NOTE

The elevated permissions provided by the **AdministratorAccess** policy are required only during installation.

Verification

When the cluster deployment completes successfully:

- The terminal displays directions for accessing your cluster, including a link to the web console and credentials for the **kubeadmin** user.
- Credential information also outputs to **<installation_directory>/.openshift_install.log**.

IMPORTANT

Do not delete the installation program or the files that the installation program creates. Both are required to delete the cluster.

Example output

```
...
INFO Install complete!
INFO To access the cluster as the system:admin user when using 'oc', run 'export
KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
INFO Access the OpenShift web-console here: https://console-openshift-
```

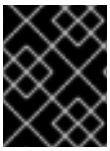
```
console.apps.mycluster.example.com
INFO Login to the console with user: "kubeadmin", and password: "password"
INFO Time elapsed: 36m22s
```

IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

5.9.9. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.



IMPORTANT

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.11. Download and install the new version of **oc**.

Installing the OpenShift CLI on Linux

You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the architecture in the **Product Variant** drop-down menu.
3. Select the appropriate version in the **Version** drop-down menu.
4. Click **Download Now** next to the **OpenShift v4.11 Linux Client** entry and save the file.
5. Unpack the archive:

   ```
   $ tar xvf <file>
   ```

6. Place the **oc** binary in a directory that is on your **PATH**.
   To check your **PATH**, execute the following command:

   ```
   $ echo $PATH
   ```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.
   To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
C:\> oc <command>
```

Installing the OpenShift CLI on macOS

You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 macOS Client** entry and save the file.

NOTE

For macOS arm64, choose the **OpenShift v4.11 macOS arm64 Client** entry.

4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your PATH.
   To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

5.9.10. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

Example output

```
system:admin
```

5.9.11. Logging in to the cluster by using the web console

The **kubeadmin** user exists by default after an OpenShift Container Platform installation. You can log in to your cluster as the **kubeadmin** user by using the OpenShift Container Platform web console.

Prerequisites

- You have access to the installation host.
- You completed a cluster installation and all cluster Operators are available.

Procedure

1. Obtain the password for the **kubeadmin** user from the **kubeadmin-password** file on the installation host:

```
$ cat <installation_directory>/auth/kubeadmin-password
```

NOTE

Alternatively, you can obtain the **kubeadmin** password from the **<installation_directory>/.openshift_install.log** log file on the installation host.

2. List the OpenShift Container Platform web console route:

```
$ oc get routes -n openshift-console | grep 'console-openshift'
```

NOTE

Alternatively, you can obtain the OpenShift Container Platform route from the **<installation_directory>/.openshift_install.log** log file on the installation host.

Example output

```
console     console-openshift-console.apps.<cluster_name>.<base_domain>           console
https   reencrypt/Redirect   None
```

3. Navigate to the route detailed in the output of the preceding command in a web browser and log in as the **kubeadmin** user.

Additional resources

- See Accessing the web console for more details about accessing and understanding the OpenShift Container Platform web console.

5.9.12. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.11, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to OpenShift Cluster Manager Hybrid Cloud Console.

After you confirm that your OpenShift Cluster Manager Hybrid Cloud Console inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, use subscription watch to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

Additional resources

- See About remote health monitoring for more information about the Telemetry service.

5.9.13. Next steps

- Validating an installation.
- Customize your cluster.
- If necessary, you can opt out of remote health reporting .

- If necessary, you can remove cloud provider credentials.

5.10. INSTALLING A CLUSTER ON AWS INTO A GOVERNMENT REGION

In OpenShift Container Platform version 4.11, you can install a cluster on Amazon Web Services (AWS) into a government region. To configure the region, modify parameters in the **install-config.yaml** file before you install the cluster.

5.10.1. Prerequisites

- You reviewed details about the OpenShift Container Platform installation and update processes.
- You read the documentation on selecting a cluster installation method and preparing it for users.
- You configured an AWS account to host the cluster.

IMPORTANT

If you have an AWS profile stored on your computer, it must not use a temporary session token that you generated while using a multi-factor authentication device. The cluster continues to use your current AWS credentials to create AWS resources for the entire life of the cluster, so you must use long-lived credentials. To generate appropriate keys, see Managing Access Keys for IAM Users in the AWS documentation. You can supply the keys when you run the installation program.

- If you use a firewall, you configured it to allow the sites that your cluster requires access to.
- If the cloud identity and access management (IAM) APIs are not accessible in your environment, or if you do not want to store an administrator-level credential secret in the **kube-system** namespace, you can manually create and maintain IAM credentials.

5.10.2. AWS government regions

OpenShift Container Platform supports deploying a cluster to an AWS GovCloud (US) region.

The following AWS GovCloud partitions are supported:

- **us-gov-east-1**
- **us-gov-west-1**

5.10.3. Installation requirements

Before you can install the cluster, you must:

- Provide an existing private AWS VPC and subnets to host the cluster.
  Public zones are not supported in Route 53 in AWS GovCloud. As a result, clusters must be private when you deploy to an AWS government region.
- Manually create the installation configuration file (**install-config.yaml**).

5.10.4. Private clusters

You can deploy a private OpenShift Container Platform cluster that does not expose external endpoints. Private clusters are accessible from only an internal network and are not visible to the internet.

NOTE

Public zones are not supported in Route 53 in an AWS GovCloud Region. Therefore, clusters must be private if they are deployed to an AWS GovCloud Region.

By default, OpenShift Container Platform is provisioned to use publicly-accessible DNS and endpoints. A private cluster sets the DNS, Ingress Controller, and API server to private when you deploy your cluster. This means that the cluster resources are only accessible from your internal network and are not visible to the internet.

IMPORTANT

If the cluster has any public subnets, load balancer services created by administrators might be publicly accessible. To ensure cluster security, verify that these services are explicitly annotated as private.

To deploy a private cluster, you must:

- Use existing networking that meets your requirements. Your cluster resources might be shared between other clusters on the network.
- Deploy from a machine that has access to:
  - The API services for the cloud to which you provision.
  - The hosts on the network that you provision.
  - The internet to obtain installation media.

You can use any machine that meets these access requirements and follows your company's guidelines. For example, this machine can be a bastion host on your cloud network or a machine that has access to the network through a VPN.

5.10.4.1. Private clusters in AWS

To create a private cluster on Amazon Web Services (AWS), you must provide an existing private VPC and subnets to host the cluster. The installation program must also be able to resolve the DNS records that the cluster requires. The installation program configures the Ingress Operator and API server for access from only the private network.

The cluster still requires access to internet to access the AWS APIs.

The following items are not required or created when you install a private cluster:

- Public subnets
- Public load balancers, which support public ingress
- A public Route 53 zone that matches the **baseDomain** for the cluster

The installation program does use the **baseDomain** that you specify to create a private Route 53 zone and the required records for the cluster. The cluster is configured so that the Operators do not create public records for the cluster and all cluster machines are placed in the private subnets that you specify.

5.10.4.1.1. Limitations

The ability to add public functionality to a private cluster is limited.

- You cannot make the Kubernetes API endpoints public after installation without taking additional actions, including creating public subnets in the VPC for each availability zone in use, creating a public load balancer, and configuring the control plane security groups to allow traffic from the internet on 6443 (Kubernetes API port).
- If you use a public Service type load balancer, you must tag a public subnet in each availability zone with **kubernetes.io/cluster/<cluster-infra-id>: shared** so that AWS can use them to create public load balancers.

5.10.5. About using a custom VPC

In OpenShift Container Platform 4.11, you can deploy a cluster into existing subnets in an existing Amazon Virtual Private Cloud (VPC) in Amazon Web Services (AWS). By deploying OpenShift Container Platform into an existing AWS VPC, you might be able to avoid limit constraints in new accounts or more easily abide by the operational constraints that your company's guidelines set. If you cannot obtain the infrastructure creation permissions that are required to create the VPC yourself, use this installation option.

Because the installation program cannot know what other components are also in your existing subnets, it cannot choose subnet CIDRs and so forth on your behalf. You must configure networking for the subnets that you install your cluster to yourself.

5.10.5.1. Requirements for using your VPC

The installation program no longer creates the following components:

- Internet gateways
- NAT gateways
- Subnets
- Route tables
- VPCs
- VPC DHCP options
- VPC endpoints

NOTE

The installation program requires that you use the cloud-provided DNS server. Using a custom DNS server is not supported and causes the installation to fail.

If you use a custom VPC, you must correctly configure it and its subnets for the installation program and the cluster to use. See Amazon VPC console wizard configurations and Work with VPCs and subnets in the AWS documentation for more information on creating and managing an AWS VPC.

The installation program cannot:

- Subdivide network ranges for the cluster to use.
- Set route tables for the subnets.
- Set VPC options like DHCP.

You must complete these tasks before you install the cluster. See VPC networking components and Route tables for your VPC for more information on configuring networking in an AWS VPC.

Your VPC must meet the following characteristics:

- The VPC must not use the **kubernetes.io/cluster/.*: owned**, **Name**, and **openshift.io/cluster** tags.
  The installation program modifies your subnets to add the **kubernetes.io/cluster/.*: shared** tag, so your subnets must have at least one free tag slot available for it. See Tag Restrictions in the AWS documentation to confirm that the installation program can add a tag to each subnet that you specify. You cannot use a **Name** tag, because it overlaps with the EC2 **Name** field and the installation fails.
- You must enable the **enableDnsSupport** and **enableDnsHostnames** attributes in your VPC, so that the cluster can use the Route 53 zones that are attached to the VPC to resolve cluster's internal DNS records. See DNS Support in Your VPC in the AWS documentation.
  If you prefer to use your own Route 53 hosted private zone, you must associate the existing hosted zone with your VPC prior to installing a cluster. You can define your hosted zone using the **platform.aws.hostedZone** field in the **install-config.yaml** file.

If you are working in a disconnected environment, you are unable to reach the public IP addresses for EC2, ELB, and S3 endpoints. Depending on the level to which you want to restrict internet traffic during the installation, the following configuration options are available:

Option 1: Create VPC endpoints
Create a VPC endpoint and attach it to the subnets that the clusters are using. Name the endpoints as follows:

- **ec2.<region>.amazonaws.com**
- **elasticloadbalancing.<region>.amazonaws.com**
- **s3.<region>.amazonaws.com**

With this option, network traffic remains private between your VPC and the required AWS services.

Option 2: Create a proxy without VPC endpoints
As part of the installation process, you can configure an HTTP or HTTPS proxy. With this option, internet traffic goes through the proxy to reach the required AWS services.

Option 3: Create a proxy with VPC endpoints
As part of the installation process, you can configure an HTTP or HTTPS proxy with VPC endpoints. Create a VPC endpoint and attach it to the subnets that the clusters are using. Name the endpoints as follows:

- **ec2.<region>.amazonaws.com**
- **elasticloadbalancing.<region>.amazonaws.com**
- **s3.<region>.amazonaws.com**

When configuring the proxy in the **install-config.yaml** file, add these endpoints to the **noProxy** field. With this option, the proxy prevents the cluster from accessing the internet directly. However, network traffic remains private between your VPC and the required AWS services.

Required VPC components

You must provide a suitable VPC and subnets that allow communication to your machines.

<table>
<tr><th>Component</th><th>AWS type</th><th>Description</th></tr>
<tr><td>VPC</td><td>AWS::EC2::VPC
AWS::EC2::VPCEndpoint</td><td>You must provide a public VPC for the cluster to use. The VPC uses an endpoint that references the route tables for each subnet to improve communication with the registry that is hosted in S3.</td></tr>
<tr><td>Public subnets</td><td>AWS::EC2::Subnet
AWS::EC2::SubnetNetworkAclAssociation</td><td>Your VPC must have public subnets for between 1 and 3 availability zones and associate them with appropriate Ingress rules.</td></tr>
<tr><td>Internet gateway</td><td>AWS::EC2::InternetGateway
AWS::EC2::VPCGatewayAttachment
AWS::EC2::RouteTable
AWS::EC2::Route
AWS::EC2::SubnetRouteTableAssociation
AWS::EC2::NatGateway
AWS::EC2::EIP</td><td>You must have a public internet gateway, with public routes, attached to the VPC. In the provided templates, each public subnet has a NAT gateway with an EIP address. These NAT gateways allow cluster resources, like private subnet instances, to reach the internet and are not required for some restricted network or proxy scenarios.</td></tr>
<tr><td>Network access control</td><td>AWS::EC2::NetworkAcl
AWS::EC2::NetworkAclEntry</td><td>You must allow the VPC to access the following ports:<table><tr><th>Port</th><th>Reason</th></tr><tr><td>80</td><td>Inbound HTTP traffic</td></tr></table></td></tr>
</table>

Component	AWS type	Description	
		443	Inbound HTTPS traffic
		22	Inbound SSH traffic
		1024 - **65535**	Inbound ephemeral traffic
		0 - **65535**	Outbound ephemeral traffic
Private subnets	• **AWS::EC2::Subnet** • **AWS::EC2::RouteTable** • **AWS::EC2::SubnetRouteTableAssociation**	Your VPC can have private subnets. The provided CloudFormation templates can create private subnets for between 1 and 3 availability zones. If you use private subnets, you must provide appropriate routes and tables for them.	

5.10.5.2. VPC validation

To ensure that the subnets that you provide are suitable, the installation program confirms the following data:

- All the subnets that you specify exist.
- You provide private subnets.
- The subnet CIDRs belong to the machine CIDR that you specified.
- You provide subnets for each availability zone. Each availability zone contains no more than one public and one private subnet. If you use a private cluster, provide only a private subnet for each availability zone. Otherwise, provide exactly one public and private subnet for each availability zone.
- You provide a public subnet for each private subnet availability zone. Machines are not provisioned in availability zones that you do not provide private subnets for.

If you destroy a cluster that uses an existing VPC, the VPC is not deleted. When you remove the OpenShift Container Platform cluster from a VPC, the **kubernetes.io/cluster/.*: shared** tag is removed from the subnets that it used.

5.10.5.3. Division of permissions

Starting with OpenShift Container Platform 4.3, you do not need all of the permissions that are required for an installation program-provisioned infrastructure cluster to deploy a cluster. This change mimics the division of permissions that you might have at your company: some individuals can create different

resource in your clouds than others. For example, you might be able to create application-specific items, like instances, buckets, and load balancers, but not networking-related components such as VPCs, subnets, or ingress rules.

The AWS credentials that you use when you create your cluster do not need the networking permissions that are required to make VPCs and core networking components within the VPC, such as subnets, routing tables, internet gateways, NAT, and VPN. You still need permission to make the application resources that the machines within the cluster require, such as ELBs, security groups, S3 buckets, and nodes.

5.10.5.4. Isolation between clusters

If you deploy OpenShift Container Platform to an existing network, the isolation of cluster services is reduced in the following ways:

- You can install multiple OpenShift Container Platform clusters in the same VPC.
- ICMP ingress is allowed from the entire network.
- TCP 22 ingress (SSH) is allowed to the entire network.
- Control plane TCP 6443 ingress (Kubernetes API) is allowed to the entire network.
- Control plane TCP 22623 ingress (MCS) is allowed to the entire network.

5.10.6. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.11, you require access to the internet to install your cluster.

You must have internet access to:

- Access OpenShift Cluster Manager Hybrid Cloud Console to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access Quay.io to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.

IMPORTANT

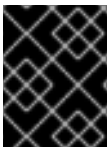
If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

5.10.7. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the **~/.ssh/authorized_keys** list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The **./openshift-install gather** command also requires the SSH public key to be in place on the cluster nodes.



IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.

NOTE

You must use a local key, not one that you configured with platform-specific approaches such as AWS key pairs.

Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N '' -f <path>/<file_name> 1
```

1 Specify the path and file name, such as ~/**.ssh/id_ed25519**, of the new SSH key. If you have an existing key pair, ensure your public key is in the your ~/**.ssh** directory.

NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS validated or Modules In Process cryptographic libraries on the **x86_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the ~/**.ssh/id_ed25519.pub** public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the **./openshift-install gather** command.

NOTE

On some distributions, default SSH private key identities such as ~/**.ssh/id_rsa** and ~/**.ssh/id_dsa** are managed automatically.

a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

Example output

```
Agent pid 31874
```

NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

1 Specify the path and file name for your SSH private key, such as **~/.ssh/id_ed25519**

Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

5.10.8. Obtaining an AWS Marketplace image

If you are deploying an OpenShift Container Platform cluster using an AWS Marketplace image, you must first subscribe through AWS. Subscribing to the offer provides you with the AMI ID that the installation program uses to deploy worker nodes.

Prerequisites

- You have an AWS account to purchase the offer. This account does not have to be the same account that is used to install the cluster.

Procedure

1. Complete the OpenShift Container Platform subscription from the AWS Marketplace.
2. Record the AMI ID for your specific region. As part of the installation process, you must update the **install-config.yaml** file with this value before deploying the cluster.

Sample install-config.yaml file with AWS Marketplace worker nodes

```
apiVersion: v1
baseDomain: example.com
```

```
compute:
- hyperthreading: Enabled
  name: worker
  platform:
    aws:
      amiID: ami-06c4d345f7c207239 (1)
      type: m5.4xlarge
  replicas: 3
metadata:
  name: test-cluster
platform:
  aws:
    region: us-east-2 (2)
sshKey: ssh-ed25519 AAAA...
pullSecret: '{"auths": ...}'
```

1. The AMI ID from your AWS Marketplace subscription.
2. Your AMI ID is associated with a specific AWS region. When creating the installation configuration file, ensure that you select the same AWS region that you specified when configuring your subscription.

5.10.9. Obtaining the installation program

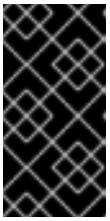
Before you install OpenShift Container Platform, download the installation file on a local computer.

Prerequisites

- You have a computer that runs Linux or macOS, with 500 MB of local disk space.

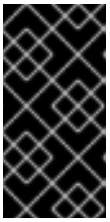
Procedure

1. Access the Infrastructure Provider page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program that corresponds with your host operating system and architecture, and place the file in the directory where you will store the installation configuration files.



IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.



IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation pull secret from the Red Hat OpenShift Cluster Manager . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

5.10.10. Manually creating the installation configuration file

Installing the cluster requires that you manually generate the installation configuration file.

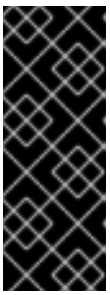
Prerequisites

- You have an SSH public key on your local machine to provide to the installation program. The key will be used for SSH authentication onto your cluster nodes for debugging and disaster recovery.
- You have obtained the OpenShift Container Platform installation program and the pull secret for your cluster.

Procedure

1. Create an installation directory to store your required installation assets in:

```
$ mkdir <installation_directory>
```



IMPORTANT

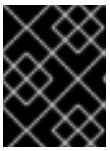
You must create a directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

2. Customize the sample **install-config.yaml** file template that is provided and save it in the **<installation_directory>**.

NOTE

You must name this configuration file **install-config.yaml**.

3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.

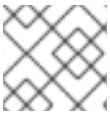


IMPORTANT

The **install-config.yaml** file is consumed during the next step of the installation process. You must back it up now.

5.10.10.1. Installation configuration parameters

Before you deploy an OpenShift Container Platform cluster, you provide parameter values to describe your account on the cloud platform that hosts your cluster and optionally customize your cluster's platform. When you create the **install-config.yaml** installation configuration file, you provide values for the required parameters through the command line. If you customize your cluster, you can modify the **install-config.yaml** file to provide more details about the platform.



NOTE

After installation, you cannot modify these parameters in the **install-config.yaml** file.

5.10.10.1.1. Required configuration parameters

Required installation configuration parameters are described in the following table:

Table 5.33. Required parameters

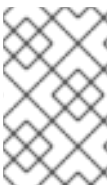
Parameter	Description	Values
apiVersion	The API version for the **install-config.yaml** content. The current version is **v1**. The installer may also support older API versions.	String
baseDomain	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the **baseDomain** and **metadata.name** parameter values that uses the **<metadata.name>.<baseDomain>** format.	A fully-qualified domain or subdomain name, such as **example.com**.
metadata	Kubernetes resource **ObjectMeta**, from which only the **name** parameter is consumed.	Object

Parameter	Description	Values
metadata.name	The name of the cluster. DNS records for the cluster are all subdomains of **{{.metadata.name}}.{{.baseDomain}}**.	String of lowercase letters, hyphens (**-**), and periods (**.**), such as **dev**.
platform	The configuration for the specific platform upon which to perform the installation: **alibabacloud**, **aws**, **baremetal**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**. For additional information about **platform.<platform>** parameters, consult the table for your specific platform that follows.	Object
pullSecret	Get a pull secret from the Red Hat OpenShift Cluster Manager to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	<pre>{ "auths":{ "cloud.openshift.com":{ "auth":"b3Blb=", "email":"you@example.com" }, "quay.io":{ "auth":"b3Blb=", "email":"you@example.com" } } }</pre>

5.10.10.1.2. Network configuration parameters

You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

Only IPv4 addresses are supported.



NOTE

Globalnet is not supported with Red Hat OpenShift Data Foundation disaster recovery solutions. For regional disaster recovery scenarios, ensure that you use a nonoverlapping range of private IP addresses for the cluster and service networks in each cluster.

Table 5.34. Network parameters

Parameter	Description	Values
networking	The configuration for the cluster network.	Object  **NOTE** You cannot modify parameters specified by the **networking** object after installation.
networking.networkType	The cluster network provider Container Network Interface (CNI) cluster network provider to install.	Either **OpenShiftSDN** or **OVNKubernetes**. **OpenShiftSDN** is a CNI provider for all-Linux networks. **OVNKubernetes** is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is **OpenShiftSDN**.
networking.clusterNetwork	The IP address blocks for pods. The default value is **10.128.0.0/14** with a host prefix of **/23**. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: `networking:` `  clusterNetwork:` `  - cidr: 10.128.0.0/14` `    hostPrefix: 23`
networking.clusterNetwork.cidr	Required if you use **networking.clusterNetwork**. An IP address block. An IPv4 network.	An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between **0** and **32**.
networking.clusterNetwork.hostPrefix	The subnet prefix length to assign to each individual node. For example, if **hostPrefix** is set to **23** then each node is assigned a **/23** subnet out of the given **cidr**. A **hostPrefix** value of **23** provides 510 (2^(32 - 23) - 2) pod IP addresses.	A subnet prefix. The default value is **23**.
networking.serviceNetwork	The IP address block for services. The default value is **172.30.0.0/16**. The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.	An array with an IP address block in CIDR format. For example: `networking:` `  serviceNetwork:` `  - 172.30.0.0/16`

Parameter	Description	Values
networking.machineNetwork	The IP address blocks for machines. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: networking: machineNetwork: - cidr: 10.0.0.0/16
networking.machineNetwork.cidr	Required if you use **networking.machineNetwork**. An IP address block. The default value is **10.0.0.0/16** for all platforms other than libvirt. For libvirt, the default value is **192.168.126.0/24**.	An IP network block in CIDR notation. For example, **10.0.0.0/16**. **NOTE** Set the **networking.machineNetwork** to match the CIDR that the preferred NIC resides in.

5.10.10.1.3. Optional configuration parameters

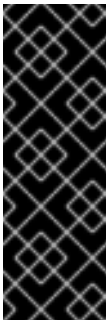
Optional installation configuration parameters are described in the following table:

Table 5.35. Optional parameters

Parameter	Description	Values
additionalTrustBundle	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String
capabilities	Controls the installation of optional core cluster components. You can reduce the footprint of your OpenShift Container Platform cluster by disabling optional components.	String array

Parameter	Description	Values
capabilities.baselineCapabilitySet	Selects an initial set of optional capabilities to enable. Valid values are **None**, **v4.11** and **vCurrent**. **v4.11** enables the **baremetal** Operator, the **marketplace** Operator, and the **openshift-samples** content. **vCurrent** installs the recommended set of capabilities for the current version of OpenShift Container Platform. The default value is **vCurrent**.	String
capabilities.additionalEnabledCapabilities	Extends the set of optional capabilities beyond what you specify in **baselineCapabilitySet**. Valid values are **baremetal**, **marketplace** and **openshift-samples**. You may specify multiple capabilities in this parameter.	String array
cgroupsV2	Enables Linux control groups version 2 (cgroups v2) on specific nodes in your cluster. The OpenShift Container Platform process for enabling cgroups v2 disables all cgroup version 1 controllers and hierarchies. The OpenShift Container Platform cgroups version 2 feature is in Developer Preview and is not supported by Red Hat at this time.	**true**
compute	The configuration for the machines that comprise the compute nodes.	Array of **MachinePool** objects.
compute.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** and **arm64**. Not all installation options support the 64-bit ARM architecture. To verify if your installation option is supported on your platform, see *Supported installation methods for different platforms* in *Selecting a cluster installation method and preparing it for users*.	String

Parameter	Description	Values
compute.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  **IMPORTANT** If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
compute.name	Required if you use **compute**. The name of the machine pool.	**worker**
compute.platform	Required if you use **compute**. Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the **controlPlane.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
compute.replicas	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to **2**. The default value is **3**.
controlPlane	The configuration for the machines that comprise the control plane.	Array of **MachinePool** objects.

Parameter	Description	Values
controlPlane.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** and **arm64**. Not all installation options support the 64-bit ARM architecture. To verify if your installation option is supported on your platform, see *Supported installation methods for different platforms* in *Selecting a cluster installation method and preparing it for users*.	String
controlPlane.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  IMPORTANT If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
controlPlane.name	Required if you use **controlPlane**. The name of the machine pool.	**master**
controlPlane.platform	Required if you use **controlPlane**. Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the **compute.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
controlPlane.replicas	The number of control plane machines to provision.	The only supported value is **3**, which is the default value.

Parameter	Description	Values
credentialsMode	The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported.  **NOTE** Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the *Cloud Credential Operator* entry in the *Cluster Operators reference* content.  **NOTE** If your AWS account has service control policies (SCP) enabled, you must configure the **credentialsMode** parameter to **Mint**, **Passthrough** or **Manual**.	**Mint**, **Passthrough**, **Manual** or an empty string (**""**).

Parameter	Description	Values
fips	Enable or disable FIPS mode. The default is **false** (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.  **IMPORTANT** To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.  **NOTE** If you are using Azure File storage, you cannot enable FIPS mode.	**false** or **true**
imageContentSources	Sources and repositories for the release-image content.	Array of objects. Includes a **source** and, optionally, **mirrors**, as described in the following rows of this table.
imageContentSources.source	Required if you use **imageContentSources**. Specify the repository that users refer to, for example, in image pull specifications.	String

Parameter	Description	Values
imageContentSources.mirrors	Specify one or more repositories that may also contain the same images.	Array of strings
publish	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	**Internal** or **External**. To deploy a private cluster, which cannot be accessed from the internet, set **publish** to **Internal**. The default value is **External**.
sshKey	The SSH key to authenticate access to your cluster machines.  **NOTE** For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.	For example, **sshKey: ssh-ed25519 AAAA..**.

5.10.10.1.4. Optional AWS configuration parameters

Optional AWS configuration parameters are described in the following table:

Table 5.36. Optional AWS parameters

Parameter	Description	Values
compute.platform.aws.amiID	The AWS AMI used to boot compute machines for the cluster. This is required for regions that require a custom RHCOS AMI.	Any published or custom RHCOS AMI that belongs to the set AWS region. See *RHCOS AMIs for AWS infrastructure* for available AMI IDs.

Parameter	Description	Values
compute.platform.aws.iamRole	A pre-existing AWS IAM role applied to the compute machine pool instance profiles. You can use these fields to match naming schemes and include predefined permissions boundaries for your IAM roles. If undefined, the installation program creates a new IAM role.	The name of a valid AWS IAM role.
compute.platform.aws.rootVolume.iops	The Input/Output Operations Per Second (IOPS) that is reserved for the root volume.	Integer, for example **4000**.
compute.platform.aws.rootVolume.size	The size in GiB of the root volume.	Integer, for example **500**.
compute.platform.aws.rootVolume.type	The type of the root volume.	Valid AWS EBS volume type, such as **io1**.
compute.platform.aws.rootVolume.kmsKeyARN	The Amazon Resource Name (key ARN) of a KMS key. This is required to encrypt OS volumes of worker nodes with a specific KMS key.	Valid key ID or the key ARN
compute.platform.aws.type	The EC2 instance type for the compute machines.	Valid AWS instance type, such as **m4.2xlarge**. See the **Supported AWS machine types** table that follows.
compute.platform.aws.zones	The availability zones where the installation program creates machines for the compute machine pool. If you provide your own VPC, you must provide a subnet in that availability zone.	A list of valid AWS availability zones, such as **us-east-1c**, in a YAML sequence.

Parameter	Description	Values
compute.aws.region	The AWS region that the installation program creates compute resources in.	Any valid AWS region, such as **us-east-1**. You can use the AWS CLI to access the regions available based on your selected instance type. For example: `aws ec2 describe-instance-type-offerings --filters Name=instance-type,Values=c7g.xlarge`  **IMPORTANT** When running on ARM based AWS instances, ensure that you enter a region where AWS Graviton processors are available. See Global availability map in the AWS documentation. Currently, AWS Graviton3 processors are only available in some regions.
controlPlane.platform.aws.amiID	The AWS AMI used to boot control plane machines for the cluster. This is required for regions that require a custom RHCOS AMI.	Any published or custom RHCOS AMI that belongs to the set AWS region. See *RHCOS AMIs for AWS infrastructure* for available AMI IDs.
controlPlane.platform.aws.iamRole	A pre-existing AWS IAM role applied to the control plane machine pool instance profiles. You can use these fields to match naming schemes and include predefined permissions boundaries for your IAM roles. If undefined, the installation program creates a new IAM role.	The name of a valid AWS IAM role.
controlPlane.platform.aws.rootVolume.kmsKeyARN	The Amazon Resource Name (key ARN) of a KMS key. This is required to encrypt OS volumes of control plane nodes with a specific KMS key.	Valid key ID and the key ARN
controlPlane.platform.aws.type	The EC2 instance type for the control plane machines.	Valid AWS instance type, such as **m6i.xlarge**. See the **Supported AWS machine types** table that follows.

Parameter	Description	Values
controlPlane.platform.aws.zones	The availability zones where the installation program creates machines for the control plane machine pool.	A list of valid AWS availability zones, such as **us-east-1c**, in a YAML sequence.
controlPlane.aws.region	The AWS region that the installation program creates control plane resources in.	Valid AWS region, such as **us-east-1**.
platform.aws.amiID	The AWS AMI used to boot all machines for the cluster. If set, the AMI must belong to the same region as the cluster. This is required for regions that require a custom RHCOS AMI.	Any published or custom RHCOS AMI that belongs to the set AWS region. See *RHCOS AMIs for AWS infrastructure* for available AMI IDs.
platform.aws.hostedZone	An existing Route 53 private hosted zone for the cluster. You can only use a pre-existing hosted zone when also supplying your own VPC. The hosted zone must already be associated with the user-provided VPC before installation. Also, the domain of the hosted zone must be the cluster domain or a parent of the cluster domain. If undefined, the installation program creates a new hosted zone.	String, for example **Z3URY6TWQ91KVV**.
platform.aws.serviceEndpoints.name	The AWS service endpoint name. Custom endpoints are only required for cases where alternative AWS endpoints, like FIPS, must be used. Custom API endpoints can be specified for EC2, S3, IAM, Elastic Load Balancing, Tagging, Route 53, and STS AWS services.	Valid AWS service endpoint name.
platform.aws.serviceEndpoints.url	The AWS service endpoint URL. The URL must use the **https** protocol and the host must trust the certificate.	Valid AWS service endpoint URL.

Parameter	Description	Values
platform.aws.userTags	A map of keys and values that the installation program adds as tags to all resources that it creates.	Any valid YAML map, such as key value pairs in the **<key>: <value>** format. For more information about AWS tags, see Tagging Your Amazon EC2 Resources in the AWS documentation.
platform.aws.subnets	If you provide the VPC instead of allowing the installation program to create the VPC for you, specify the subnet for the cluster to use. The subnet must be part of the same **machineNetwork[].cidr** ranges that you specify. For a standard cluster, specify a public and a private subnet for each availability zone. For a private cluster, specify a private subnet for each availability zone.	Valid subnet IDs.

5.10.10.2. Minimum resource requirements for cluster installation

Each cluster machine must meet the following minimum requirements:

Table 5.37. Minimum resource requirements

Machine	Operating System	vCPU [1]	Virtual RAM	Storage	IOPS [2]
Bootstrap	RHCOS	4	16 GB	100 GB	300
Control plane	RHCOS	4	16 GB	100 GB	300
Compute	RHCOS, RHEL 8.6 and later [3]	2	8 GB	100 GB	300

1. One vCPU is equivalent to one physical core when simultaneous multithreading (SMT), or hyperthreading, is not enabled. When enabled, use the following formula to calculate the corresponding ratio: (threads per core × cores) × sockets = vCPUs.

2. OpenShift Container Platform and Kubernetes are sensitive to disk performance, and faster storage is recommended, particularly for etcd on the control plane nodes which require a 10 ms p99 fsync duration. Note that on many cloud platforms, storage size and IOPS scale together, so you might need to over-allocate storage volume to obtain sufficient performance.

3. As with all user-provisioned installations, if you choose to use RHEL compute machines in your cluster, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks.

Use of RHEL 7 compute machines is deprecated and has been removed in OpenShift Container Platform 4.10 and later.

If an instance type for your platform meets the minimum requirements for cluster machines, it is supported to use in OpenShift Container Platform.

Additional resources

- Optimizing storage

5.10.10.3. Tested instance types for AWS

The following Amazon Web Services (AWS) instance types have been tested with OpenShift Container Platform.

NOTE

Use the machine types included in the following charts for your AWS instances. If you use an instance type that is not listed in the chart, ensure that the instance size you use matches the minimum resource requirements that are listed in "Minimum resource requirements for cluster installation".

Example 5.24. Machine types based on 64-bit x86 architecture

- **c4.***
- **c5.***
- **c5a.***
- **i3.***
- **m4.***
- **m5.***
- **m5a.***
- **m6a.***
- **m6i.***
- **r4.***
- **r5.***
- **r5a.***
- **r6i.***
- **t3.***
- **t3a.***

5.10.10.4. Tested instance types for AWS on 64-bit ARM infrastructures

The following Amazon Web Services (AWS) ARM64 instance types have been tested with OpenShift Container Platform.

NOTE

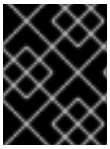
Use the machine types included in the following charts for your AWS ARM instances. If you use an instance type that is not listed in the chart, ensure that the instance size you use matches the minimum resource requirements that are listed in "Minimum resource requirements for cluster installation".

Example 5.25. Machine types based on 64-bit ARM architecture

- **c6g.***
- **m6g.***

5.10.10.5. Sample customized install-config.yaml file for AWS

You can customize the installation configuration file (**install-config.yaml**) to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.



IMPORTANT

This sample YAML file is provided for reference only. Use it as a resource to enter parameter values into the installation configuration file that you created manually.

```
apiVersion: v1
baseDomain: example.com (1)
credentialsMode: Mint (2)
controlPlane: (3) (4)
  hyperthreading: Enabled (5)
  name: master
  platform:
    aws:
      zones:
      - us-gov-west-1a
      - us-gov-west-1b
      rootVolume:
        iops: 4000
        size: 500
        type: io1 (6)
      metadataService:
        authentication: Optional (7)
      type: m6i.xlarge
  replicas: 3
compute: (8)
- hyperthreading: Enabled (9)
  name: worker
  platform:
    aws:
```

```
      rootVolume:
        iops: 2000
        size: 500
        type: io1 10
      metadataService:
        authentication: Optional 11
      type: c5.4xlarge
      zones:
      - us-gov-west-1c
  replicas: 3
metadata:
  name: test-cluster 12
networking:
  clusterNetwork:
  - cidr: 10.128.0.0/14
    hostPrefix: 23
  machineNetwork:
  - cidr: 10.0.0.0/16
  networkType: OpenShiftSDN
  serviceNetwork:
  - 172.30.0.0/16
platform:
  aws:
    region: us-gov-west-1 13
    userTags:
      adminContact: jdoe
      costCenter: 7536
    subnets: 14
    - subnet-1
    - subnet-2
    - subnet-3
    amiID: ami-96c6f8f7 15
    serviceEndpoints: 16
      - name: ec2
        url: https://vpce-id.ec2.us-west-2.vpce.amazonaws.com
    hostedZone: Z3URY6TWQ91KVV 17
fips: false 18
sshKey: ssh-ed25519 AAAA... 19
publish: Internal 20
pullSecret: '{"auths": ...}' 21
```

1 12 13 21 Required.

2 Optional: Add this parameter to force the Cloud Credential Operator (CCO) to use the specified mode, instead of having the CCO dynamically try to determine the capabilities of the credentials. For details about CCO modes, see the *Cloud Credential Operator* entry in the *Red Hat Operators reference* content.

3 8 If you do not provide these parameters and values, the installation program provides the default value.

4 The **controlPlane** section is a single mapping, but the **compute** section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, **-**, and the first line of the **controlPlane** section must not. Only one control plane pool is used.

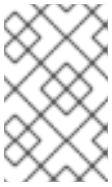
5 9 Whether to enable or disable simultaneous multithreading, or **hyperthreading**. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores. You

IMPORTANT

If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance. Use larger instance types, such as **m4.2xlarge** or **m5.2xlarge**, for your machines if you disable simultaneous multithreading.

6 10 To configure faster storage for etcd, especially for larger clusters, set the storage type as **io1** and set **iops** to **2000**.

7 11 Whether to require the Amazon EC2 Instance Metadata Service v2 (IMDSv2). To require IMDSv2, set the parameter value to **Required**. To allow the use of both IMDSv1 and IMDSv2, set the parameter value to **Optional**. If no value is specified, both IMDSv1 and IMDSv2 are allowed.



NOTE

The IMDS configuration for control plane machines that is set during cluster installation can only be changed by using the AWS CLI. The IMDS configuration for compute machines can be changed by using machine sets.

14 If you provide your own VPC, specify subnets for each availability zone that your cluster uses.

15 The ID of the AMI used to boot machines for the cluster. If set, the AMI must belong to the same region as the cluster.

16 The AWS service endpoints. Custom endpoints are required when installing to an unknown AWS region. The endpoint URL must use the **https** protocol and the host must trust the certificate.

17 The ID of your existing Route 53 private hosted zone. Providing an existing hosted zone requires that you supply your own VPC and the hosted zone is already associated with the VPC prior to installing your cluster. If undefined, the installation program creates a new hosted zone.

18 Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.

IMPORTANT

To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.

19 You can optionally provide the **sshKey** value that you use to access the machines in your cluster.

NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

20 How to publish the user-facing endpoints of your cluster. Set **publish** to **Internal** to deploy a private cluster, which cannot be accessed from the internet. The default value is **External**.

5.10.10.6. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.

NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: ec2.<region>.amazonaws.com,elasticloadbalancing.
<region>.amazonaws.com,s3.<region>.amazonaws.com 3
additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
```

1 A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.

2 A proxy URL to use for creating HTTPS connections outside the cluster.

3 A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use ***** to bypass the proxy for all destinations. If you have added the Amazon **EC2**,**Elastic Load Balancing**, and **S3** VPC endpoints to your VPC, you must add these endpoints to the **noProxy** field.

4 If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace that contains one or more additional CA certificates that are required for proxying HTTPS connections. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges these contents with the Red Hat Enterprise Linux CoreOS (RHCOS) trust bundle, and this config map is referenced in the **trustedCA** field of the **Proxy** object. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.

NOTE

The installation program does not support the proxy **readinessEndpoints** field.

NOTE

If the installer times out, restart and then complete the deployment by using the **wait-for** command of the installer. For example:

```
$ ./openshift-install wait-for install-complete --log-level debug
```

2. Save the file and reference it when installing OpenShift Container Platform.

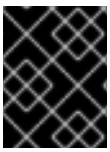
The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.

NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

5.10.11. Deploying the cluster

You can install OpenShift Container Platform on a compatible cloud platform.



IMPORTANT

You can run the **create cluster** command of the installation program only once, during initial installation.

Prerequisites

- Configure an account with the cloud platform that hosts your cluster.

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.

Procedure

1. Change to the directory that contains the installation program and initialize the cluster deployment:

```
$ ./openshift-install create cluster --dir <installation_directory> \ 1
    --log-level=info 2
```

1 For **<installation_directory>**, specify the location of your customized **./install-config.yaml** file.

2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

NOTE

If the cloud provider account that you configured on your host does not have sufficient permissions to deploy the cluster, the installation process stops, and the missing permissions are displayed.

2. Optional: Remove or disable the **AdministratorAccess** policy from the IAM account that you used to install the cluster.

NOTE

The elevated permissions provided by the **AdministratorAccess** policy are required only during installation.

Verification

When the cluster deployment completes successfully:

- The terminal displays directions for accessing your cluster, including a link to the web console and credentials for the **kubeadmin** user.
- Credential information also outputs to **<installation_directory>/.openshift_install.log**.

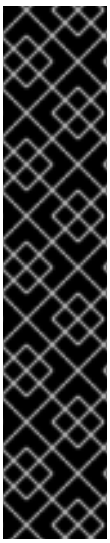
IMPORTANT

Do not delete the installation program or the files that the installation program creates. Both are required to delete the cluster.

Example output

```
...
INFO Install complete!
INFO To access the cluster as the system:admin user when using 'oc', run 'export
KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
INFO Access the OpenShift web-console here: https://console-openshift-
```

```
console.apps.mycluster.example.com
INFO Login to the console with user: "kubeadmin", and password: "password"
INFO Time elapsed: 36m22s
```



IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

5.10.12. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.

IMPORTANT

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.11. Download and install the new version of **oc**.

Installing the OpenShift CLI on Linux

You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the architecture in the **Product Variant** drop-down menu.
3. Select the appropriate version in the **Version** drop-down menu.
4. Click **Download Now** next to the **OpenShift v4.11 Linux Client** entry and save the file.
5. Unpack the archive:

   ```
   $ tar xvf <file>
   ```

6. Place the **oc** binary in a directory that is on your **PATH**.
   To check your **PATH**, execute the following command:

   ```
   $ echo $PATH
   ```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.
   To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

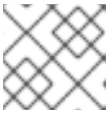
```
C:\> oc <command>
```

Installing the OpenShift CLI on macOS

You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 macOS Client** entry and save the file.



NOTE

For macOS arm64, choose the **OpenShift v4.11 macOS arm64 Client** entry.

4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your PATH.
   To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

5.10.13. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

Example output

```
system:admin
```

5.10.14. Logging in to the cluster by using the web console

The **kubeadmin** user exists by default after an OpenShift Container Platform installation. You can log in to your cluster as the **kubeadmin** user by using the OpenShift Container Platform web console.

Prerequisites

- You have access to the installation host.
- You completed a cluster installation and all cluster Operators are available.

Procedure

1. Obtain the password for the **kubeadmin** user from the **kubeadmin-password** file on the installation host:

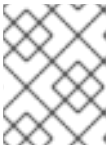
```
$ cat <installation_directory>/auth/kubeadmin-password
```

NOTE

Alternatively, you can obtain the **kubeadmin** password from the **<installation_directory>/.openshift_install.log** log file on the installation host.

2. List the OpenShift Container Platform web console route:

```
$ oc get routes -n openshift-console | grep 'console-openshift'
```



NOTE

Alternatively, you can obtain the OpenShift Container Platform route from the **<installation_directory>/.openshift_install.log** log file on the installation host.

Example output

```
console     console-openshift-console.apps.<cluster_name>.<base_domain>           console
https   reencrypt/Redirect   None
```

3. Navigate to the route detailed in the output of the preceding command in a web browser and log in as the **kubeadmin** user.

Additional resources

- See Accessing the web console for more details about accessing and understanding the OpenShift Container Platform web console.

5.10.15. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.11, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to OpenShift Cluster Manager Hybrid Cloud Console.

After you confirm that your OpenShift Cluster Manager Hybrid Cloud Console inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, use subscription watch to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

Additional resources

- See About remote health monitoring for more information about the Telemetry service.

5.10.16. Next steps

- Validating an installation.
- Customize your cluster.
- If necessary, you can opt out of remote health reporting .

- If necessary, you can remove cloud provider credentials.

5.11. INSTALLING A CLUSTER ON AWS INTO A SECRET OR TOP SECRET REGION

In OpenShift Container Platform version 4.11, you can install a cluster on Amazon Web Services (AWS) into the following secret regions:

- Secret Commercial Cloud Services (SC2S)
- Commercial Cloud Services (C2S)

To configure a cluster in either region, you change parameters in the **install config.yaml** file before you install the cluster.

5.11.1. Prerequisites

- You reviewed details about the OpenShift Container Platform installation and update processes.
- You read the documentation on selecting a cluster installation method and preparing it for users.
- You configured an AWS account to host the cluster.

IMPORTANT

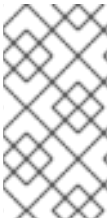
If you have an AWS profile stored on your computer, it must not use a temporary session token that you generated while using a multifactor authentication device. The cluster continues to use your current AWS credentials to create AWS resources for the entire life of the cluster, so you must use long-lived credentials. To generate appropriate keys, see Managing Access Keys for IAM Users in the AWS documentation. You can supply the keys when you run the installation program.

- If you use a firewall, you configured it to allow the sites that your cluster requires access to.
- If the cloud identity and access management (IAM) APIs are not accessible in your environment, or if you do not want to store an administrator-level credential secret in the **kube-system** namespace, you can manually create and maintain IAM credentials.

5.11.2. AWS secret regions

The following AWS secret partitions are supported:

- **us-isob-east-1** (SC2S)
- **us-iso-east-1** (C2S)



NOTE

The maximum supported MTU in an AWS SC2S and C2S Regions is not the same as AWS commercial. For more information about configuring MTU during installation, see the *Cluster Network Operator configuration object* section in *Installing a cluster on AWS with network customizations*

5.11.3. Installation requirements

Red Hat does not publish a Red Hat Enterprise Linux CoreOS (RHCOS) Amzaon Machine Image for the AWS Secret and Top Secret Regions.

Before you can install the cluster, you must:

- Upload a custom RHCOS AMI.
- Manually create the installation configuration file (**install-config.yaml**).
- Specify the AWS region, and the accompanying custom AMI, in the installation configuration file.

You cannot use the OpenShift Container Platform installation program to create the installation configuration file. The installer does not list an AWS region without native support for an RHCOS AMI.

IMPORTANT

You must also define a custom CA certificate in the **additionalTrustBundle** field of the **install-config.yaml** file because the AWS API requires a custom CA trust bundle. To allow the installation program to access the AWS API, the CA certificates must also be defined on the machine that runs the installation program. You must add the CA bundle to the trust store on the machine, use the **AWS_CA_BUNDLE** environment variable, or define the CA bundle in the **ca_bundle** field of the AWS config file.

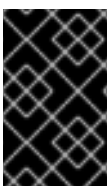
5.11.4. Private clusters

You can deploy a private OpenShift Container Platform cluster that does not expose external endpoints. Private clusters are accessible from only an internal network and are not visible to the internet.

NOTE

Public zones are not supported in Route 53 in an AWS Top Secret Region. Therefore, clusters must be private if they are deployed to an AWS Top Secret Region.

By default, OpenShift Container Platform is provisioned to use publicly-accessible DNS and endpoints. A private cluster sets the DNS, Ingress Controller, and API server to private when you deploy your cluster. This means that the cluster resources are only accessible from your internal network and are not visible to the internet.



IMPORTANT

If the cluster has any public subnets, load balancer services created by administrators might be publicly accessible. To ensure cluster security, verify that these services are explicitly annotated as private.

To deploy a private cluster, you must:

- Use existing networking that meets your requirements. Your cluster resources might be shared between other clusters on the network.
- Deploy from a machine that has access to:
  - The API services for the cloud to which you provision.
  - The hosts on the network that you provision.
  - The internet to obtain installation media.

You can use any machine that meets these access requirements and follows your company's guidelines. For example, this machine can be a bastion host on your cloud network or a machine that has access to the network through a VPN.

5.11.4.1. Private clusters in AWS

To create a private cluster on Amazon Web Services (AWS), you must provide an existing private VPC and subnets to host the cluster. The installation program must also be able to resolve the DNS records that the cluster requires. The installation program configures the Ingress Operator and API server for access from only the private network.

The cluster still requires access to internet to access the AWS APIs.

The following items are not required or created when you install a private cluster:

- Public subnets
- Public load balancers, which support public ingress
- A public Route 53 zone that matches the **baseDomain** for the cluster

The installation program does use the **baseDomain** that you specify to create a private Route 53 zone and the required records for the cluster. The cluster is configured so that the Operators do not create public records for the cluster and all cluster machines are placed in the private subnets that you specify.

5.11.4.1.1. Limitations

The ability to add public functionality to a private cluster is limited.

- You cannot make the Kubernetes API endpoints public after installation without taking additional actions, including creating public subnets in the VPC for each availability zone in use, creating a public load balancer, and configuring the control plane security groups to allow traffic from the internet on 6443 (Kubernetes API port).
- If you use a public Service type load balancer, you must tag a public subnet in each availability zone with **kubernetes.io/cluster/<cluster-infra-id>: shared** so that AWS can use them to create public load balancers.

5.11.5. About using a custom VPC

In OpenShift Container Platform 4.11, you can deploy a cluster into existing subnets in an existing Amazon Virtual Private Cloud (VPC) in Amazon Web Services (AWS). By deploying OpenShift Container Platform into an existing AWS VPC, you might be able to avoid limit constraints in new

accounts or more easily abide by the operational constraints that your company's guidelines set. If you cannot obtain the infrastructure creation permissions that are required to create the VPC yourself, use this installation option.

Because the installation program cannot know what other components are also in your existing subnets, it cannot choose subnet CIDRs and so forth on your behalf. You must configure networking for the subnets that you install your cluster to yourself.

5.11.5.1. Requirements for using your VPC

The installation program no longer creates the following components:

- Internet gateways
- NAT gateways
- Subnets
- Route tables
- VPCs
- VPC DHCP options
- VPC endpoints

NOTE

The installation program requires that you use the cloud-provided DNS server. Using a custom DNS server is not supported and causes the installation to fail.

If you use a custom VPC, you must correctly configure it and its subnets for the installation program and the cluster to use. See Amazon VPC console wizard configurations and Work with VPCs and subnets in the AWS documentation for more information on creating and managing an AWS VPC.

The installation program cannot:

- Subdivide network ranges for the cluster to use.
- Set route tables for the subnets.
- Set VPC options like DHCP.

You must complete these tasks before you install the cluster. See VPC networking components and Route tables for your VPC for more information on configuring networking in an AWS VPC.

Your VPC must meet the following characteristics:

- The VPC must not use the **kubernetes.io/cluster/.*: owned**, **Name**, and **openshift.io/cluster** tags.
  The installation program modifies your subnets to add the **kubernetes.io/cluster/.*: shared** tag, so your subnets must have at least one free tag slot available for it. See Tag Restrictions in the AWS documentation to confirm that the installation program can add a tag to each subnet that you specify. You cannot use a **Name** tag, because it overlaps with the EC2 **Name** field and the installation fails.

- You must enable the **enableDnsSupport** and **enableDnsHostnames** attributes in your VPC, so that the cluster can use the Route 53 zones that are attached to the VPC to resolve cluster's internal DNS records. See DNS Support in Your VPC in the AWS documentation.
  If you prefer to use your own Route 53 hosted private zone, you must associate the existing hosted zone with your VPC prior to installing a cluster. You can define your hosted zone using the **platform.aws.hostedZone** field in the **install-config.yaml** file.

A cluster in an SC2S or C2S Region is unable to reach the public IP addresses for the EC2, ELB, and S3 endpoints. Depending on the level to which you want to restrict internet traffic during the installation, the following configuration options are available:

Option 1: Create VPC endpoints
Create a VPC endpoint and attach it to the subnets that the clusters are using. Name the endpoints as follows:

SC2S

- **elasticloadbalancing.<region>.sc2s.sgov.gov**
- **ec2.<region>.sc2s.sgov.gov**
- **s3.<region>.sc2s.sgov.gov**

C2S

- **elasticloadbalancing.<region>.c2s.ic.gov**
- **ec2.<region>.c2s.ic.gov**
- **s3.<region>.c2s.ic.gov**

With this option, network traffic remains private between your VPC and the required AWS services.

Option 2: Create a proxy without VPC endpoints
As part of the installation process, you can configure an HTTP or HTTPS proxy. With this option, internet traffic goes through the proxy to reach the required AWS services.

Option 3: Create a proxy with VPC endpoints
As part of the installation process, you can configure an HTTP or HTTPS proxy with VPC endpoints. Create a VPC endpoint and attach it to the subnets that the clusters are using. Name the endpoints as follows:

SC2S

- **elasticloadbalancing.<region>.sc2s.sgov.gov**
- **ec2.<region>.sc2s.sgov.gov**
- **s3.<region>.sc2s.sgov.gov**

C2S

- **elasticloadbalancing.<region>.c2s.ic.gov**
- **ec2.<region>.c2s.ic.gov**
- **s3.<region>.c2s.ic.gov**

When configuring the proxy in the **install-config.yaml** file, add these endpoints to the **noProxy** field. With this option, the proxy prevents the cluster from accessing the internet directly. However, network traffic remains private between your VPC and the required AWS services.

Required VPC components

You must provide a suitable VPC and subnets that allow communication to your machines.

<table>
<tr><th>Component</th><th>AWS type</th><th>Description</th></tr>
<tr><td>VPC</td><td>AWS::EC2::VPC
AWS::EC2::VPCEndpoint</td><td>You must provide a public VPC for the cluster to use. The VPC uses an endpoint that references the route tables for each subnet to improve communication with the registry that is hosted in S3.</td></tr>
<tr><td>Public subnets</td><td>AWS::EC2::Subnet
AWS::EC2::SubnetNetworkAclAssociation</td><td>Your VPC must have public subnets for between 1 and 3 availability zones and associate them with appropriate Ingress rules.</td></tr>
<tr><td>Internet gateway</td><td>AWS::EC2::InternetGateway
AWS::EC2::VPCGatewayAttachment
AWS::EC2::RouteTable
AWS::EC2::Route
AWS::EC2::SubnetRouteTableAssociation
AWS::EC2::NatGateway
AWS::EC2::EIP</td><td>You must have a public internet gateway, with public routes, attached to the VPC. In the provided templates, each public subnet has a NAT gateway with an EIP address. These NAT gateways allow cluster resources, like private subnet instances, to reach the internet and are not required for some restricted network or proxy scenarios.</td></tr>
<tr><td>Network access control</td><td>AWS::EC2::NetworkAcl
AWS::EC2::NetworkAclEntry</td><td>You must allow the VPC to access the following ports:<table><tr><th>Port</th><th>Reason</th></tr><tr><td>80</td><td>Inbound HTTP traffic</td></tr><tr><td>443</td><td>Inbound HTTPS traffic</td></tr><tr><td>22</td><td>Inbound SSH traffic</td></tr></table></td></tr>
</table>

Component	AWS type	Description	
		1024 - 65535	Inbound ephemeral traffic
		0 - 65535	Outbound ephemeral traffic
Private subnets	• **AWS::EC2::Subnet** • **AWS::EC2::RouteTable** • **AWS::EC2::SubnetRouteTableAssociation**	Your VPC can have private subnets. The provided CloudFormation templates can create private subnets for between 1 and 3 availability zones. If you use private subnets, you must provide appropriate routes and tables for them.	

5.11.5.2. VPC validation

To ensure that the subnets that you provide are suitable, the installation program confirms the following data:

- All the subnets that you specify exist.
- You provide private subnets.
- The subnet CIDRs belong to the machine CIDR that you specified.
- You provide subnets for each availability zone. Each availability zone contains no more than one public and one private subnet. If you use a private cluster, provide only a private subnet for each availability zone. Otherwise, provide exactly one public and private subnet for each availability zone.
- You provide a public subnet for each private subnet availability zone. Machines are not provisioned in availability zones that you do not provide private subnets for.

If you destroy a cluster that uses an existing VPC, the VPC is not deleted. When you remove the OpenShift Container Platform cluster from a VPC, the **kubernetes.io/cluster/.*: shared** tag is removed from the subnets that it used.

5.11.5.3. Division of permissions

Starting with OpenShift Container Platform 4.3, you do not need all of the permissions that are required for an installation program-provisioned infrastructure cluster to deploy a cluster. This change mimics the division of permissions that you might have at your company: some individuals can create different resource in your clouds than others. For example, you might be able to create application-specific items, like instances, buckets, and load balancers, but not networking-related components such as VPCs, subnets, or ingress rules.

The AWS credentials that you use when you create your cluster do not need the networking permissions that are required to make VPCs and core networking components within the VPC, such as subnets, routing tables, internet gateways, NAT, and VPN. You still need permission to make the application

resources that the machines within the cluster require, such as ELBs, security groups, S3 buckets, and nodes.

5.11.5.4. Isolation between clusters

If you deploy OpenShift Container Platform to an existing network, the isolation of cluster services is reduced in the following ways:

- You can install multiple OpenShift Container Platform clusters in the same VPC.
- ICMP ingress is allowed from the entire network.
- TCP 22 ingress (SSH) is allowed to the entire network.
- Control plane TCP 6443 ingress (Kubernetes API) is allowed to the entire network.
- Control plane TCP 22623 ingress (MCS) is allowed to the entire network.

5.11.6. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.11, you require access to the internet to install your cluster.

You must have internet access to:

- Access OpenShift Cluster Manager Hybrid Cloud Console to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access Quay.io to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.

IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

5.11.7. Uploading a custom RHCOS AMI in AWS

If you are deploying to a custom Amazon Web Services (AWS) region, you must upload a custom Red Hat Enterprise Linux CoreOS (RHCOS) Amazon Machine Image (AMI) that belongs to that region.

Prerequisites

- You configured an AWS account.
- You created an Amazon S3 bucket with the required IAM service role.
- You uploaded your RHCOS VMDK file to Amazon S3. The RHCOS VMDK file must be the highest version that is less than or equal to the OpenShift Container Platform version you are installing.

- You downloaded the AWS CLI and installed it on your computer. See Install the AWS CLI Using the Bundled Installer.

Procedure

1. Export your AWS profile as an environment variable:

```
$ export AWS_PROFILE=<aws_profile> 1
```

2. Export the region to associate with your custom AMI as an environment variable:

```
$ export AWS_DEFAULT_REGION=<aws_region> 1
```

3. Export the version of RHCOS you uploaded to Amazon S3 as an environment variable:

```
$ export RHCOS_VERSION=<version> 1
```

1 1 1 The RHCOS VMDK version, like **4.11.0**.

4. Export the Amazon S3 bucket name as an environment variable:

```
$ export VMIMPORT_BUCKET_NAME=<s3_bucket_name>
```

5. Create the **containers.json** file and define your RHCOS VMDK file:

```
$ cat <<EOF > containers.json
{
  "Description": "rhcos-${RHCOS_VERSION}-x86_64-aws.x86_64",
  "Format": "vmdk",
  "UserBucket": {
    "S3Bucket": "${VMIMPORT_BUCKET_NAME}",
    "S3Key": "rhcos-${RHCOS_VERSION}-x86_64-aws.x86_64.vmdk"
  }
}
EOF
```

6. Import the RHCOS disk as an Amazon EBS snapshot:

```
$ aws ec2 import-snapshot --region ${AWS_DEFAULT_REGION} \
    --description "<description>" \ 1
    --disk-container "file://<file_path>/containers.json" 2
```

1 The description of your RHCOS disk being imported, like **rhcos-${RHCOS_VERSION}-x86_64-aws.x86_64**.

2 The file path to the JSON file describing your RHCOS disk. The JSON file should contain your Amazon S3 bucket name and key.

7. Check the status of the image import:

```
$ watch -n 5 aws ec2 describe-import-snapshot-tasks --region ${AWS_DEFAULT_REGION}
```

Example output

```
{
    "ImportSnapshotTasks": [
        {
            "Description": "rhcos-4.7.0-x86_64-aws.x86_64",
            "ImportTaskId": "import-snap-fh6i8uil",
            "SnapshotTaskDetail": {
                "Description": "rhcos-4.7.0-x86_64-aws.x86_64",
                "DiskImageSize": 819056640.0,
                "Format": "VMDK",
                "SnapshotId": "snap-06331325870076318",
                "Status": "completed",
                "UserBucket": {
                    "S3Bucket": "external-images",
                    "S3Key": "rhcos-4.7.0-x86_64-aws.x86_64.vmdk"
                }
            }
        }
    ]
}
```

Copy the **SnapshotId** to register the image.

8. Create a custom RHCOS AMI from the RHCOS snapshot:

```
$ aws ec2 register-image \
  --region ${AWS_DEFAULT_REGION} \
  --architecture x86_64 \ 1
  --description "rhcos-${RHCOS_VERSION}-x86_64-aws.x86_64" \ 2
  --ena-support \
  --name "rhcos-${RHCOS_VERSION}-x86_64-aws.x86_64" \ 3
  --virtualization-type hvm \
  --root-device-name '/dev/xvda' \
  --block-device-mappings 'DeviceName=/dev/xvda,Ebs=
{DeleteOnTermination=true,SnapshotId=<snapshot_ID>}' 4
```

1. The RHCOS VMDK architecture type, like **x86_64**, **aarch64**, **s390x**, or **ppc64le**.
2. The **Description** from the imported snapshot.
3. The name of the RHCOS AMI.
4. The **SnapshotID** from the imported snapshot.

To learn more about these APIs, see the AWS documentation for importing snapshots and creating EBS-backed AMIs.

5.11.8. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added

to the ~/**.ssh/authorized_keys** list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The **./openshift-install gather** command also requires the SSH public key to be in place on the cluster nodes.

IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.

NOTE

You must use a local key, not one that you configured with platform-specific approaches such as AWS key pairs.

Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N '' -f <path>/<file_name> 1
```

1 Specify the path and file name, such as ~/**.ssh/id_ed25519**, of the new SSH key. If you have an existing key pair, ensure your public key is in the your ~/**.ssh** directory.

NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS validated or Modules In Process cryptographic libraries on the **x86_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

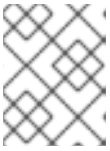
2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the ~/**.ssh/id_ed25519.pub** public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the **./openshift-install gather** command.



NOTE

On some distributions, default SSH private key identities such as ~/**.ssh/id_rsa** and ~/**.ssh/id_dsa** are managed automatically.

a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

Example output

```
Agent pid 31874
```

NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

1 Specify the path and file name for your SSH private key, such as ~/**.ssh/id_ed25519**

Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

5.11.9. Obtaining the installation program

Before you install OpenShift Container Platform, download the installation file on a local computer.

Prerequisites

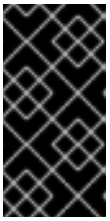
- You have a computer that runs Linux or macOS, with 500 MB of local disk space.

Procedure

1. Access the Infrastructure Provider page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.

2. Select your infrastructure provider.

3. Navigate to the page for your installation type, download the installation program that corresponds with your host operating system and architecture, and place the file in the directory where you will store the installation configuration files.



IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.

IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation pull secret from the Red Hat OpenShift Cluster Manager . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

5.11.10. Manually creating the installation configuration file

Installing the cluster requires that you manually generate the installation configuration file.

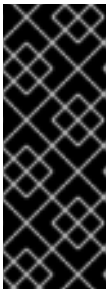
Prerequisites

- You have uploaded a custom RHCOS AMI.
- You have an SSH public key on your local machine to provide to the installation program. The key will be used for SSH authentication onto your cluster nodes for debugging and disaster recovery.
- You have obtained the OpenShift Container Platform installation program and the pull secret for your cluster.

Procedure

1. Create an installation directory to store your required installation assets in:

```
$ mkdir <installation_directory>
```



IMPORTANT

You must create a directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

2. Customize the sample **install-config.yaml** file template that is provided and save it in the **<installation_directory>**.

NOTE

You must name this configuration file **install-config.yaml**.

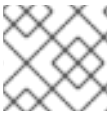
3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.

IMPORTANT

The **install-config.yaml** file is consumed during the next step of the installation process. You must back it up now.

5.11.10.1. Installation configuration parameters

Before you deploy an OpenShift Container Platform cluster, you provide parameter values to describe your account on the cloud platform that hosts your cluster and optionally customize your cluster's platform. When you create the **install-config.yaml** installation configuration file, you provide values for the required parameters through the command line. If you customize your cluster, you can modify the **install-config.yaml** file to provide more details about the platform.



NOTE

After installation, you cannot modify these parameters in the **install-config.yaml** file.

5.11.10.1.1. Required configuration parameters

Required installation configuration parameters are described in the following table:

Table 5.38. Required parameters

Parameter	Description	Values
apiVersion	The API version for the **install-config.yaml** content. The current version is **v1**. The installer may also support older API versions.	String

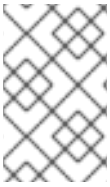
Parameter	Description	Values
baseDomain	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the **baseDomain** and **metadata.name** parameter values that uses the **<metadata.name>.<baseDomain>** format.	A fully-qualified domain or subdomain name, such as **example.com**.
metadata	Kubernetes resource **ObjectMeta**, from which only the **name** parameter is consumed.	Object
metadata.name	The name of the cluster. DNS records for the cluster are all subdomains of **{{.metadata.name}}.{{.baseDomain}}**.	String of lowercase letters, hyphens (**-**), and periods (**.**), such as **dev**.
platform	The configuration for the specific platform upon which to perform the installation: **alibabacloud**, **aws**, **baremetal**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**. For additional information about **platform.<platform>** parameters, consult the table for your specific platform that follows.	Object

Parameter	Description	Values
pullSecret	Get a pull secret from the Red Hat OpenShift Cluster Manager to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	<pre>{ "auths":{ "cloud.openshift.com":{ "auth":"b3Blb=", "email":"you@example.com" }, "quay.io":{ "auth":"b3Blb=", "email":"you@example.com" } } }</pre>

5.11.10.1.2. Network configuration parameters

You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

Only IPv4 addresses are supported.



NOTE

Globalnet is not supported with Red Hat OpenShift Data Foundation disaster recovery solutions. For regional disaster recovery scenarios, ensure that you use a nonoverlapping range of private IP addresses for the cluster and service networks in each cluster.

Table 5.39. Network parameters

Parameter	Description	Values
networking	The configuration for the cluster network.	Object  **NOTE** You cannot modify parameters specified by the **networking** object after installation.

Parameter	Description	Values
networking.networkType	The cluster network provider Container Network Interface (CNI) cluster network provider to install.	Either **OpenShiftSDN** or **OVNKubernetes**. **OpenShiftSDN** is a CNI provider for all-Linux networks. **OVNKubernetes** is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is **OpenShiftSDN**.
networking.clusterNetwork	The IP address blocks for pods. The default value is **10.128.0.0/14** with a host prefix of **/23**. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: `networking:` `  clusterNetwork:` `  - cidr: 10.128.0.0/14` `    hostPrefix: 23`
networking.clusterNetwork.cidr	Required if you use **networking.clusterNetwork**. An IP address block. An IPv4 network.	An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between **0** and **32**.
networking.clusterNetwork.hostPrefix	The subnet prefix length to assign to each individual node. For example, if **hostPrefix** is set to **23** then each node is assigned a **/23** subnet out of the given **cidr**. A **hostPrefix** value of **23** provides 510 (2^(32 - 23) - 2) pod IP addresses.	A subnet prefix. The default value is **23**.
networking.serviceNetwork	The IP address block for services. The default value is **172.30.0.0/16**. The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.	An array with an IP address block in CIDR format. For example: `networking:` `  serviceNetwork:` `   - 172.30.0.0/16`
networking.machineNetwork	The IP address blocks for machines. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: `networking:` `  machineNetwork:` `  - cidr: 10.0.0.0/16`

Parameter	Description	Values
networking.machineNetwork.cidr	Required if you use **networking.machineNetwork**. An IP address block. The default value is **10.0.0.0/16** for all platforms other than libvirt. For libvirt, the default value is **192.168.126.0/24**.	An IP network block in CIDR notation. For example, **10.0.0.0/16**.  **NOTE** Set the **networking.machineNetwork** to match the CIDR that the preferred NIC resides in.

5.11.10.1.3. Optional configuration parameters

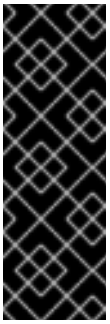
Optional installation configuration parameters are described in the following table:

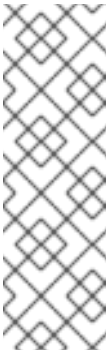
Table 5.40. Optional parameters

Parameter	Description	Values
additionalTrustBundle	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String
capabilities	Controls the installation of optional core cluster components. You can reduce the footprint of your OpenShift Container Platform cluster by disabling optional components.	String array
capabilities.baselineCapabilitySet	Selects an initial set of optional capabilities to enable. Valid values are **None**, **v4.11** and **vCurrent**. **v4.11** enables the **baremetal** Operator, the **marketplace** Operator, and the **openshift-samples** content. **vCurrent** installs the recommended set of capabilities for the current version of OpenShift Container Platform. The default value is **vCurrent**.	String

Parameter	Description	Values
capabilities.additionalEnabledCapabilities	Extends the set of optional capabilities beyond what you specify in **baselineCapabilitySet**. Valid values are **baremetal**, **marketplace** and **openshift-samples**. You may specify multiple capabilities in this parameter.	String array
cgroupsV2	Enables Linux control groups version 2 (cgroups v2) on specific nodes in your cluster. The OpenShift Container Platform process for enabling cgroups v2 disables all cgroup version 1 controllers and hierarchies. The OpenShift Container Platform cgroups version 2 feature is in Developer Preview and is not supported by Red Hat at this time.	**true**
compute	The configuration for the machines that comprise the compute nodes.	Array of **MachinePool** objects.
compute.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** and **arm64**. Not all installation options support the 64-bit ARM architecture. To verify if your installation option is supported on your platform, see *Supported installation methods for different platforms* in *Selecting a cluster installation method and preparing it for users*.	String

Parameter	Description	Values
compute.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  **IMPORTANT** If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
compute.name	Required if you use **compute**. The name of the machine pool.	**worker**
compute.platform	Required if you use **compute**. Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the **controlPlane.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
compute.replicas	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to **2**. The default value is **3**.
controlPlane	The configuration for the machines that comprise the control plane.	Array of **MachinePool** objects.

Parameter	Description	Values
controlPlane.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** and **arm64**. Not all installation options support the 64-bit ARM architecture. To verify if your installation option is supported on your platform, see *Supported installation methods for different platforms* in *Selecting a cluster installation method and preparing it for users*.	String
controlPlane.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  **IMPORTANT** If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
controlPlane.name	Required if you use **controlPlane**. The name of the machine pool.	**master**
controlPlane.platform	Required if you use **controlPlane**. Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the **compute.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
controlPlane.replicas	The number of control plane machines to provision.	The only supported value is **3**, which is the default value.

Parameter	Description	Values
credentialsMode	The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported.  **NOTE** Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the *Cloud Credential Operator* entry in the *Cluster Operators reference* content.  **NOTE** If your AWS account has service control policies (SCP) enabled, you must configure the **credentialsMode** parameter to **Mint**, **Passthrough** or **Manual**.	**Mint**, **Passthrough**, **Manual** or an empty string (**""**).

Parameter	Description	Values
fips	Enable or disable FIPS mode. The default is **false** (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.  **IMPORTANT** To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.  **NOTE** If you are using Azure File storage, you cannot enable FIPS mode.	**false** or **true**

Parameter	Description	Values
imageContentSources	Sources and repositories for the release-image content.	Array of objects. Includes a **source** and, optionally, **mirrors**, as described in the following rows of this table.
imageContentSources.source	Required if you use **imageContentSources**. Specify the repository that users refer to, for example, in image pull specifications.	String
imageContentSources.mirrors	Specify one or more repositories that may also contain the same images.	Array of strings
publish	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	**Internal** or **External**. To deploy a private cluster, which cannot be accessed from the internet, set **publish** to **Internal**. The default value is **External**.
sshKey	The SSH key to authenticate access to your cluster machines.  **NOTE** For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.	For example, **sshKey: ssh-ed25519 AAAA..**.

5.11.10.1.4. Optional AWS configuration parameters

Optional AWS configuration parameters are described in the following table:

Table 5.41. Optional AWS parameters

Parameter	Description	Values
compute.platform.aws.amiID	The AWS AMI used to boot compute machines for the cluster. This is required for regions that require a custom RHCOS AMI.	Any published or custom RHCOS AMI that belongs to the set AWS region. See *RHCOS AMIs for AWS infrastructure* for available AMI IDs.

Parameter	Description	Values
compute.platform.aws.iamRole	A pre-existing AWS IAM role applied to the compute machine pool instance profiles. You can use these fields to match naming schemes and include predefined permissions boundaries for your IAM roles. If undefined, the installation program creates a new IAM role.	The name of a valid AWS IAM role.
compute.platform.aws.rootVolume.iops	The Input/Output Operations Per Second (IOPS) that is reserved for the root volume.	Integer, for example **4000**.
compute.platform.aws.rootVolume.size	The size in GiB of the root volume.	Integer, for example **500**.
compute.platform.aws.rootVolume.type	The type of the root volume.	Valid AWS EBS volume type, such as **io1**.
compute.platform.aws.rootVolume.kmsKeyARN	The Amazon Resource Name (key ARN) of a KMS key. This is required to encrypt OS volumes of worker nodes with a specific KMS key.	Valid key ID or the key ARN
compute.platform.aws.type	The EC2 instance type for the compute machines.	Valid AWS instance type, such as **m4.2xlarge**. See the **Supported AWS machine types** table that follows.
compute.platform.aws.zones	The availability zones where the installation program creates machines for the compute machine pool. If you provide your own VPC, you must provide a subnet in that availability zone.	A list of valid AWS availability zones, such as **us-east-1c**, in a YAML sequence.

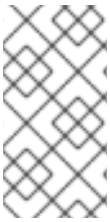
Parameter	Description	Values
compute.aws.region	The AWS region that the installation program creates compute resources in.	Any valid AWS region, such as **us-east-1**. You can use the AWS CLI to access the regions available based on your selected instance type. For example: `aws ec2 describe-instance-type-offerings --filters Name=instance-type,Values=c7g.xlarge`  **IMPORTANT** When running on ARM based AWS instances, ensure that you enter a region where AWS Graviton processors are available. See Global availability map in the AWS documentation. Currently, AWS Graviton3 processors are only available in some regions.
controlPlane.platform.aws.amiID	The AWS AMI used to boot control plane machines for the cluster. This is required for regions that require a custom RHCOS AMI.	Any published or custom RHCOS AMI that belongs to the set AWS region. See *RHCOS AMIs for AWS infrastructure* for available AMI IDs.
controlPlane.platform.aws.iamRole	A pre-existing AWS IAM role applied to the control plane machine pool instance profiles. You can use these fields to match naming schemes and include predefined permissions boundaries for your IAM roles. If undefined, the installation program creates a new IAM role.	The name of a valid AWS IAM role.
controlPlane.platform.aws.rootVolume.kmsKeyARN	The Amazon Resource Name (key ARN) of a KMS key. This is required to encrypt OS volumes of control plane nodes with a specific KMS key.	Valid key ID and the key ARN

Parameter	Description	Values
controlPlane.platform.aws.type	The EC2 instance type for the control plane machines.	Valid AWS instance type, such as **m6i.xlarge**. See the **Supported AWS machine types** table that follows.
controlPlane.platform.aws.zones	The availability zones where the installation program creates machines for the control plane machine pool.	A list of valid AWS availability zones, such as **us-east-1c**, in a YAML sequence.
controlPlane.aws.region	The AWS region that the installation program creates control plane resources in.	Valid AWS region, such as **us-east-1**.
platform.aws.amiID	The AWS AMI used to boot all machines for the cluster. If set, the AMI must belong to the same region as the cluster. This is required for regions that require a custom RHCOS AMI.	Any published or custom RHCOS AMI that belongs to the set AWS region. See *RHCOS AMIs for AWS infrastructure* for available AMI IDs.
platform.aws.hostedZone	An existing Route 53 private hosted zone for the cluster. You can only use a pre-existing hosted zone when also supplying your own VPC. The hosted zone must already be associated with the user-provided VPC before installation. Also, the domain of the hosted zone must be the cluster domain or a parent of the cluster domain. If undefined, the installation program creates a new hosted zone.	String, for example **Z3URY6TWQ91KVV**.
platform.aws.serviceEndpoints.name	The AWS service endpoint name. Custom endpoints are only required for cases where alternative AWS endpoints, like FIPS, must be used. Custom API endpoints can be specified for EC2, S3, IAM, Elastic Load Balancing, Tagging, Route 53, and STS AWS services.	Valid AWS service endpoint name.

Parameter	Description	Values
platform.aws.serviceEndpoints.url	The AWS service endpoint URL. The URL must use the **https** protocol and the host must trust the certificate.	Valid AWS service endpoint URL.
platform.aws.userTags	A map of keys and values that the installation program adds as tags to all resources that it creates.	Any valid YAML map, such as key value pairs in the **<key>: <value>** format. For more information about AWS tags, see Tagging Your Amazon EC2 Resources in the AWS documentation.
platform.aws.subnets	If you provide the VPC instead of allowing the installation program to create the VPC for you, specify the subnet for the cluster to use. The subnet must be part of the same **machineNetwork[].cidr** ranges that you specify. For a standard cluster, specify a public and a private subnet for each availability zone. For a private cluster, specify a private subnet for each availability zone.	Valid subnet IDs.

5.11.10.2. Tested instance types for AWS

The following Amazon Web Services (AWS) instance types have been tested with OpenShift Container Platform.



NOTE

Use the machine types included in the following charts for your AWS instances. If you use an instance type that is not listed in the chart, ensure that the instance size you use matches the minimum resource requirements that are listed in "Minimum resource requirements for cluster installation".

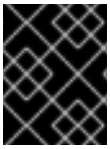
Example 5.26. Machine types based on 64-bit x86 architecture for secret regions

- **c4.***
- **c5.***
- **i3.***
- **m4.***
- **m5.***
- **r4.***

- **r5.***
- **t3.***

5.11.10.3. Sample customized install-config.yaml file for AWS

You can customize the installation configuration file (**install-config.yaml**) to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.



IMPORTANT

This sample YAML file is provided for reference only. Use it as a resource to enter parameter values into the installation configuration file that you created manually.

```
apiVersion: v1
baseDomain: example.com (1)
credentialsMode: Mint (2)
controlPlane: (3) (4)
  hyperthreading: Enabled (5)
  name: master
  platform:
    aws:
      zones:
      - us-iso-east-1a
      - us-iso-east-1b
      rootVolume:
        iops: 4000
        size: 500
        type: io1 (6)
      metadataService:
        authentication: Optional (7)
      type: m6i.xlarge
  replicas: 3
compute: (8)
- hyperthreading: Enabled (9)
  name: worker
  platform:
    aws:
      rootVolume:
        iops: 2000
        size: 500
        type: io1 (10)
      metadataService:
        authentication: Optional (11)
      type: c5.4xlarge
      zones:
      - us-iso-east-1a
      - us-iso-east-1b
  replicas: 3
metadata:
  name: test-cluster (12)
networking:
```

```
  clusterNetwork:
  - cidr: 10.128.0.0/14
    hostPrefix: 23
  machineNetwork:
  - cidr: 10.0.0.0/16
  networkType: OpenShiftSDN
  serviceNetwork:
  - 172.30.0.0/16
platform:
  aws:
    region: us-iso-east-1 13
    userTags:
      adminContact: jdoe
      costCenter: 7536
    subnets: 14
    - subnet-1
    - subnet-2
    - subnet-3
    amiID: ami-96c6f8f7 15 16
    serviceEndpoints: 17
      - name: ec2
        url: https://vpce-id.ec2.us-west-2.vpce.amazonaws.com
    hostedZone: Z3URY6TWQ91KVV 18
fips: false 19
sshKey: ssh-ed25519 AAAA... 20
publish: Internal 21
pullSecret: '{"auths": ...}' 22
additionalTrustBundle: | 23
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
```

1 12 13 15 22 Required.

2 Optional: Add this parameter to force the Cloud Credential Operator (CCO) to use the specified mode, instead of having the CCO dynamically try to determine the capabilities of the credentials. For details about CCO modes, see the *Cloud Credential Operator* entry in the *Red Hat Operators reference* content.

3 8 If you do not provide these parameters and values, the installation program provides the default value.

4 The **controlPlane** section is a single mapping, but the **compute** section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, **-**, and the first line of the **controlPlane** section must not. Only one control plane pool is used.

5 9 Whether to enable or disable simultaneous multithreading, or **hyperthreading**. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores. You can disable it by setting the parameter value to **Disabled**. If you disable simultaneous multithreading in some cluster machines, you must disable it in all cluster machines.

IMPORTANT

If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance. Use larger instance types, such as **m4.2xlarge** or **m5.2xlarge**, for your machines if you disable simultaneous multithreading.

6 10 To configure faster storage for etcd, especially for larger clusters, set the storage type as **io1** and set **iops** to **2000**.

7 11 Whether to require the Amazon EC2 Instance Metadata Service v2 (IMDSv2). To require IMDSv2, set the parameter value to **Required**. To allow the use of both IMDSv1 and IMDSv2, set the parameter value to **Optional**. If no value is specified, both IMDSv1 and IMDSv2 are allowed.

NOTE

The IMDS configuration for control plane machines that is set during cluster installation can only be changed by using the AWS CLI. The IMDS configuration for compute machines can be changed by using machine sets.

14 If you provide your own VPC, specify subnets for each availability zone that your cluster uses.

16 The ID of the AMI used to boot machines for the cluster. If set, the AMI must belong to the same region as the cluster.

17 The AWS service endpoints. Custom endpoints are required when installing to an unknown AWS region. The endpoint URL must use the **https** protocol and the host must trust the certificate.

18 The ID of your existing Route 53 private hosted zone. Providing an existing hosted zone requires that you supply your own VPC and the hosted zone is already associated with the VPC prior to installing your cluster. If undefined, the installation program creates a new hosted zone.

19 Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.

IMPORTANT

To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.

20 You can optionally provide the **sshKey** value that you use to access the machines in your cluster.

NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

21 How to publish the user-facing endpoints of your cluster. Set **publish** to **Internal** to deploy a private cluster, which cannot be accessed from the internet. The default value is **External**.

23 The custom CA certificate. This is required when deploying to the SC2S or C2S Regions because the AWS API requires a custom CA trust bundle.

5.11.10.4. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.

NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

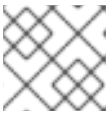
```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: ec2.<region>.amazonaws.com,elasticloadbalancing.
<region>.amazonaws.com,s3.<region>.amazonaws.com 3
additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
```

1 A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.

2 A proxy URL to use for creating HTTPS connections outside the cluster.

3 A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For

4 If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace that contains one or more additional CA certificates that are required for proxying HTTPS connections. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges these contents with the Red Hat Enterprise Linux CoreOS (RHCOS) trust bundle, and this config map is referenced in the **trustedCA** field of the **Proxy** object. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.



NOTE

The installation program does not support the proxy **readinessEndpoints** field.

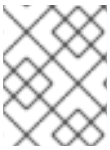
NOTE

If the installer times out, restart and then complete the deployment by using the **wait-for** command of the installer. For example:

```
$ ./openshift-install wait-for install-complete --log-level debug
```

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.



NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

5.11.11. Deploying the cluster

You can install OpenShift Container Platform on a compatible cloud platform.

IMPORTANT

You can run the **create cluster** command of the installation program only once, during initial installation.

Prerequisites

- Configure an account with the cloud platform that hosts your cluster.
- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.

Procedure

1. Change to the directory that contains the installation program and initialize the cluster deployment:

```
$ ./openshift-install create cluster --dir <installation_directory> \ 1
    --log-level=info 2
```

1 For **<installation_directory>**, specify the location of your customized **./install-config.yaml** file.

2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

NOTE

If the cloud provider account that you configured on your host does not have sufficient permissions to deploy the cluster, the installation process stops, and the missing permissions are displayed.

2. Optional: Remove or disable the **AdministratorAccess** policy from the IAM account that you used to install the cluster.

NOTE

The elevated permissions provided by the **AdministratorAccess** policy are required only during installation.

Verification

When the cluster deployment completes successfully:

- The terminal displays directions for accessing your cluster, including a link to the web console and credentials for the **kubeadmin** user.
- Credential information also outputs to **<installation_directory>/.openshift_install.log**.

IMPORTANT

Do not delete the installation program or the files that the installation program creates. Both are required to delete the cluster.

Example output

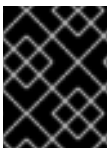
```
...
INFO Install complete!
INFO To access the cluster as the system:admin user when using 'oc', run 'export
KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
INFO Access the OpenShift web-console here: https://console-openshift-
console.apps.mycluster.example.com
INFO Login to the console with user: "kubeadmin", and password: "password"
INFO Time elapsed: 36m22s
```

IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

5.11.12. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.



IMPORTANT

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.11. Download and install the new version of **oc**.

Installing the OpenShift CLI on Linux

You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the architecture in the **Product Variant** drop-down menu.
3. Select the appropriate version in the **Version** drop-down menu.
4. Click **Download Now** next to the **OpenShift v4.11 Linux Client** entry and save the file.
5. Unpack the archive:

```
$ tar xvf <file>
```

6. Place the **oc** binary in a directory that is on your **PATH**.
   To check your **PATH**, execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.
   To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
C:\> oc <command>
```

Installing the OpenShift CLI on macOS

You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 macOS Client** entry and save the file.

NOTE

For macOS arm64, choose the **OpenShift v4.11 macOS arm64 Client** entry.

4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your PATH.
   To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

5.11.13. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

Example output

```
system:admin
```

5.11.14. Logging in to the cluster by using the web console

The **kubeadmin** user exists by default after an OpenShift Container Platform installation. You can log in to your cluster as the **kubeadmin** user by using the OpenShift Container Platform web console.

Prerequisites

- You have access to the installation host.
- You completed a cluster installation and all cluster Operators are available.

Procedure

1. Obtain the password for the **kubeadmin** user from the **kubeadmin-password** file on the installation host:

```
$ cat <installation_directory>/auth/kubeadmin-password
```

NOTE

Alternatively, you can obtain the **kubeadmin** password from the **<installation_directory>/.openshift_install.log** log file on the installation host.

2. List the OpenShift Container Platform web console route:

```
$ oc get routes -n openshift-console | grep 'console-openshift'
```

NOTE

Alternatively, you can obtain the OpenShift Container Platform route from the **<installation_directory>/.openshift_install.log** log file on the installation host.

Example output

```
console     console-openshift-console.apps.<cluster_name>.<base_domain>           console
https   reencrypt/Redirect   None
```

3. Navigate to the route detailed in the output of the preceding command in a web browser and log in as the **kubeadmin** user.

Additional resources

- Accessing the web console

5.11.15. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.11, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to OpenShift Cluster Manager Hybrid Cloud Console.

After you confirm that your OpenShift Cluster Manager Hybrid Cloud Console inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, use subscription watch to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

Additional resources

- About remote health monitoring

5.11.16. Next steps

- Validating an installation.
- Customize your cluster.
- If necessary, you can opt out of remote health reporting .
- If necessary, you can remove cloud provider credentials.

5.12. INSTALLING A CLUSTER ON AWS CHINA

In OpenShift Container Platform version 4.11, you can install a cluster to the following Amazon Web Services (AWS) China regions:

- **cn-north-1** (Beijing)
- **cn-northwest-1** (Ningxia)

5.12.1. Prerequisites

- You have an Internet Content Provider (ICP) license.
- You reviewed details about the OpenShift Container Platform installation and update processes.
- You read the documentation on selecting a cluster installation method and preparing it for users.
- You configured an AWS account to host the cluster.
- If you use a firewall, you configured it to allow the sites that your cluster requires access to.
- If the cloud identity and access management (IAM) APIs are not accessible in your environment, or if you do not want to store an administrator-level credential secret in the **kube-system** namespace, you can manually create and maintain IAM credentials.

IMPORTANT

If you have an AWS profile stored on your computer, it must not use a temporary session token that you generated while using a multi-factor authentication device. The cluster continues to use your current AWS credentials to create AWS resources for the entire life of the cluster, so you must use long-lived credentials. To generate appropriate keys, see Managing Access Keys for IAM Users in the AWS documentation. You can supply the keys when you run the installation program.

5.12.2. Installation requirements

Red Hat does not publish a Red Hat Enterprise Linux CoreOS (RHCOS) Amazon Machine Image (AMI) for the AWS China regions.

Before you can install the cluster, you must:

- Upload a custom RHCOS AMI.
- Manually create the installation configuration file (**install-config.yaml**).
- Specify the AWS region, and the accompanying custom AMI, in the installation configuration file.

You cannot use the OpenShift Container Platform installation program to create the installation configuration file. The installer does not list an AWS region without native support for an RHCOS AMI.

5.12.3. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.11, you require access to the internet to install your cluster.

You must have internet access to:

- Access OpenShift Cluster Manager Hybrid Cloud Console to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access Quay.io to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.

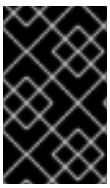
IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

5.12.4. Private clusters

You can deploy a private OpenShift Container Platform cluster that does not expose external endpoints. Private clusters are accessible from only an internal network and are not visible to the internet.

By default, OpenShift Container Platform is provisioned to use publicly-accessible DNS and endpoints. A private cluster sets the DNS, Ingress Controller, and API server to private when you deploy your cluster. This means that the cluster resources are only accessible from your internal network and are not visible to the internet.



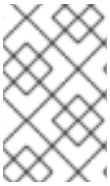
IMPORTANT

If the cluster has any public subnets, load balancer services created by administrators might be publicly accessible. To ensure cluster security, verify that these services are explicitly annotated as private.

To deploy a private cluster, you must:

- Use existing networking that meets your requirements. Your cluster resources might be shared between other clusters on the network.
- Deploy from a machine that has access to:
  - The API services for the cloud to which you provision.
  - The hosts on the network that you provision.
  - The internet to obtain installation media.

You can use any machine that meets these access requirements and follows your company's guidelines. For example, this machine can be a bastion host on your cloud network.



NOTE

AWS China does not support a VPN connection between the VPC and your network. For more information about the Amazon VPC service in the Beijing and Ningxia regions, see Amazon Virtual Private Cloud in the AWS China documentation.

5.12.4.1. Private clusters in AWS

To create a private cluster on Amazon Web Services (AWS), you must provide an existing private VPC and subnets to host the cluster. The installation program must also be able to resolve the DNS records that the cluster requires. The installation program configures the Ingress Operator and API server for access from only the private network.

The cluster still requires access to internet to access the AWS APIs.

The following items are not required or created when you install a private cluster:

- Public subnets
- Public load balancers, which support public ingress
- A public Route 53 zone that matches the **baseDomain** for the cluster

The installation program does use the **baseDomain** that you specify to create a private Route 53 zone and the required records for the cluster. The cluster is configured so that the Operators do not create public records for the cluster and all cluster machines are placed in the private subnets that you specify.

5.12.4.1.1. Limitations

The ability to add public functionality to a private cluster is limited.

- You cannot make the Kubernetes API endpoints public after installation without taking additional actions, including creating public subnets in the VPC for each availability zone in use, creating a public load balancer, and configuring the control plane security groups to allow traffic from the internet on 6443 (Kubernetes API port).
- If you use a public Service type load balancer, you must tag a public subnet in each availability zone with **kubernetes.io/cluster/<cluster-infra-id>: shared** so that AWS can use them to create public load balancers.

5.12.5. About using a custom VPC

In OpenShift Container Platform 4.11, you can deploy a cluster into existing subnets in an existing Amazon Virtual Private Cloud (VPC) in Amazon Web Services (AWS). By deploying OpenShift Container Platform into an existing AWS VPC, you might be able to avoid limit constraints in new accounts or more easily abide by the operational constraints that your company's guidelines set. If you cannot obtain the infrastructure creation permissions that are required to create the VPC yourself, use this installation option.

Because the installation program cannot know what other components are also in your existing subnets, it cannot choose subnet CIDRs and so forth on your behalf. You must configure networking for the subnets that you install your cluster to yourself.

5.12.5.1. Requirements for using your VPC

The installation program no longer creates the following components:

- Internet gateways
- NAT gateways
- Subnets
- Route tables
- VPCs
- VPC DHCP options
- VPC endpoints

NOTE

The installation program requires that you use the cloud-provided DNS server. Using a custom DNS server is not supported and causes the installation to fail.

If you use a custom VPC, you must correctly configure it and its subnets for the installation program and the cluster to use. See Amazon VPC console wizard configurations and Work with VPCs and subnets in the AWS documentation for more information on creating and managing an AWS VPC.

The installation program cannot:

- Subdivide network ranges for the cluster to use.
- Set route tables for the subnets.
- Set VPC options like DHCP.

You must complete these tasks before you install the cluster. See VPC networking components and Route tables for your VPC for more information on configuring networking in an AWS VPC.

Your VPC must meet the following characteristics:

- The VPC must not use the **kubernetes.io/cluster/.*: owned**, **Name**, and **openshift.io/cluster** tags.
  The installation program modifies your subnets to add the **kubernetes.io/cluster/.*: shared** tag, so your subnets must have at least one free tag slot available for it. See Tag Restrictions in the AWS documentation to confirm that the installation program can add a tag to each subnet that you specify. You cannot use a **Name** tag, because it overlaps with the EC2 **Name** field and the installation fails.
- You must enable the **enableDnsSupport** and **enableDnsHostnames** attributes in your VPC, so that the cluster can use the Route 53 zones that are attached to the VPC to resolve cluster's internal DNS records. See DNS Support in Your VPC in the AWS documentation.
  If you prefer to use your own Route 53 hosted private zone, you must associate the existing hosted zone with your VPC prior to installing a cluster. You can define your hosted zone using the **platform.aws.hostedZone** field in the **install-config.yaml** file.

If you are working in a disconnected environment, you are unable to reach the public IP addresses for EC2, ELB, and S3 endpoints. Depending on the level to which you want to restrict internet traffic during the installation, the following configuration options are available:

Option 1: Create VPC endpoints

Create a VPC endpoint and attach it to the subnets that the clusters are using. Name the endpoints as follows:

- **ec2.<region>.amazonaws.com.cn**
- **elasticloadbalancing.<region>.amazonaws.com**
- **s3.<region>.amazonaws.com**

With this option, network traffic remains private between your VPC and the required AWS services.

Option 2: Create a proxy without VPC endpoints
As part of the installation process, you can configure an HTTP or HTTPS proxy. With this option, internet traffic goes through the proxy to reach the required AWS services.

Option 3: Create a proxy with VPC endpoints
As part of the installation process, you can configure an HTTP or HTTPS proxy with VPC endpoints. Create a VPC endpoint and attach it to the subnets that the clusters are using. Name the endpoints as follows:

- **ec2.<region>.amazonaws.com.cn**
- **elasticloadbalancing.<region>.amazonaws.com**
- **s3.<region>.amazonaws.com**

When configuring the proxy in the **install-config.yaml** file, add these endpoints to the **noProxy** field. With this option, the proxy prevents the cluster from accessing the internet directly. However, network traffic remains private between your VPC and the required AWS services.

Required VPC components

You must provide a suitable VPC and subnets that allow communication to your machines.

Component	AWS type	Description
VPC	• **AWS::EC2::VPC** • **AWS::EC2::VPCEndpoint**	You must provide a public VPC for the cluster to use. The VPC uses an endpoint that references the route tables for each subnet to improve communication with the registry that is hosted in S3.
Public subnets	• **AWS::EC2::Subnet** • **AWS::EC2::SubnetNetworkAclAssociation**	Your VPC must have public subnets for between 1 and 3 availability zones and associate them with appropriate Ingress rules.

<table>
<tr><th>Component</th><th>AWS type</th><th>Description</th></tr>
<tr><td>Internet gateway</td><td>AWS::EC2::InternetGateway
AWS::EC2::VPCGatewayAttachment
AWS::EC2::RouteTable
AWS::EC2::Route
AWS::EC2::SubnetRouteTableAssociation
AWS::EC2::NatGateway
AWS::EC2::EIP</td><td>You must have a public internet gateway, with public routes, attached to the VPC. In the provided templates, each public subnet has a NAT gateway with an EIP address. These NAT gateways allow cluster resources, like private subnet instances, to reach the internet and are not required for some restricted network or proxy scenarios.</td></tr>
<tr><td>Network access control</td><td>AWS::EC2::NetworkAcl
AWS::EC2::NetworkAclEntry</td><td>You must allow the VPC to access the following ports:<table><tr><th>Port</th><th>Reason</th></tr><tr><td>80</td><td>Inbound HTTP traffic</td></tr><tr><td>443</td><td>Inbound HTTPS traffic</td></tr><tr><td>22</td><td>Inbound SSH traffic</td></tr><tr><td>1024 - 65535</td><td>Inbound ephemeral traffic</td></tr><tr><td>0 - 65535</td><td>Outbound ephemeral traffic</td></tr></table></td></tr>
<tr><td>Private subnets</td><td>AWS::EC2::Subnet
AWS::EC2::RouteTable
AWS::EC2::SubnetRouteTableAssociation</td><td>Your VPC can have private subnets. The provided CloudFormation templates can create private subnets for between 1 and 3 availability zones. If you use private subnets, you must provide appropriate routes and tables for them.</td></tr>
</table>

5.12.5.2. VPC validation

To ensure that the subnets that you provide are suitable, the installation program confirms the following data:

- All the subnets that you specify exist.
- You provide private subnets.
- The subnet CIDRs belong to the machine CIDR that you specified.
- You provide subnets for each availability zone. Each availability zone contains no more than one public and one private subnet. If you use a private cluster, provide only a private subnet for each availability zone. Otherwise, provide exactly one public and private subnet for each availability zone.
- You provide a public subnet for each private subnet availability zone. Machines are not provisioned in availability zones that you do not provide private subnets for.

If you destroy a cluster that uses an existing VPC, the VPC is not deleted. When you remove the OpenShift Container Platform cluster from a VPC, the **kubernetes.io/cluster/.*: shared** tag is removed from the subnets that it used.

5.12.5.3. Division of permissions

Starting with OpenShift Container Platform 4.3, you do not need all of the permissions that are required for an installation program-provisioned infrastructure cluster to deploy a cluster. This change mimics the division of permissions that you might have at your company: some individuals can create different resource in your clouds than others. For example, you might be able to create application-specific items, like instances, buckets, and load balancers, but not networking-related components such as VPCs, subnets, or ingress rules.

The AWS credentials that you use when you create your cluster do not need the networking permissions that are required to make VPCs and core networking components within the VPC, such as subnets, routing tables, internet gateways, NAT, and VPN. You still need permission to make the application resources that the machines within the cluster require, such as ELBs, security groups, S3 buckets, and nodes.

5.12.5.4. Isolation between clusters

If you deploy OpenShift Container Platform to an existing network, the isolation of cluster services is reduced in the following ways:

- You can install multiple OpenShift Container Platform clusters in the same VPC.
- ICMP ingress is allowed from the entire network.
- TCP 22 ingress (SSH) is allowed to the entire network.
- Control plane TCP 6443 ingress (Kubernetes API) is allowed to the entire network.
- Control plane TCP 22623 ingress (MCS) is allowed to the entire network.

5.12.6. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the **~/.ssh/authorized_keys** list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The **./openshift-install gather** command also requires the SSH public key to be in place on the cluster nodes.

IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.

NOTE

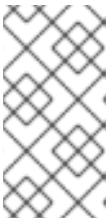
You must use a local key, not one that you configured with platform-specific approaches such as AWS key pairs.

Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N '' -f <path>/<file_name> 1
```

1 Specify the path and file name, such as ~/**.ssh/id_ed25519**, of the new SSH key. If you have an existing key pair, ensure your public key is in the your ~/**.ssh** directory.



NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS validated or Modules In Process cryptographic libraries on the **x86_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

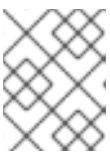
2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the ~/**.ssh/id_ed25519.pub** public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the **./openshift-install gather** command.



NOTE

On some distributions, default SSH private key identities such as ~/**.ssh/id_rsa** and ~/**.ssh/id_dsa** are managed automatically.

a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

Example output

```
Agent pid 31874
```

NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

1 Specify the path and file name for your SSH private key, such as **~/.ssh/id_ed25519**

Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

5.12.7. Uploading a custom RHCOS AMI in AWS

If you are deploying to a custom Amazon Web Services (AWS) region, you must upload a custom Red Hat Enterprise Linux CoreOS (RHCOS) Amazon Machine Image (AMI) that belongs to that region.

Prerequisites

- You configured an AWS account.
- You created an Amazon S3 bucket with the required IAM service role.
- You uploaded your RHCOS VMDK file to Amazon S3. The RHCOS VMDK file must be the highest version that is less than or equal to the OpenShift Container Platform version you are installing.
- You downloaded the AWS CLI and installed it on your computer. See Install the AWS CLI Using the Bundled Installer.

Procedure

1. Export your AWS profile as an environment variable:

```
$ export AWS_PROFILE=<aws_profile> 1
```

1 The AWS profile name that holds your AWS credentials, like **beijingadmin**.

2. Export the region to associate with your custom AMI as an environment variable:

```
$ export AWS_DEFAULT_REGION=<aws_region> 1
```

1 The AWS region, like **cn-north-1**.

3. Export the version of RHCOS you uploaded to Amazon S3 as an environment variable:

```
$ export RHCOS_VERSION=<version> 1
```

1 The RHCOS VMDK version, like **4.11.0**.

4. Export the Amazon S3 bucket name as an environment variable:

```
$ export VMIMPORT_BUCKET_NAME=<s3_bucket_name>
```

5. Create the **containers.json** file and define your RHCOS VMDK file:

```
$ cat <<EOF > containers.json
{
  "Description": "rhcos-${RHCOS_VERSION}-x86_64-aws.x86_64",
  "Format": "vmdk",
  "UserBucket": {
    "S3Bucket": "${VMIMPORT_BUCKET_NAME}",
    "S3Key": "rhcos-${RHCOS_VERSION}-x86_64-aws.x86_64.vmdk"
  }
}
EOF
```

6. Import the RHCOS disk as an Amazon EBS snapshot:

```
$ aws ec2 import-snapshot --region ${AWS_DEFAULT_REGION} \
    --description "<description>" \ 1
    --disk-container "file://<file_path>/containers.json" 2
```

1 The description of your RHCOS disk being imported, like **rhcos-${RHCOS_VERSION}-x86_64-aws.x86_64**.

2 The file path to the JSON file describing your RHCOS disk. The JSON file should contain your Amazon S3 bucket name and key.

7. Check the status of the image import:

```
$ watch -n 5 aws ec2 describe-import-snapshot-tasks --region ${AWS_DEFAULT_REGION}
```

Example output

```
{
    "ImportSnapshotTasks": [
        {
            "Description": "rhcos-4.7.0-x86_64-aws.x86_64",
            "ImportTaskId": "import-snap-fh6i8uil",
            "SnapshotTaskDetail": {
                "Description": "rhcos-4.7.0-x86_64-aws.x86_64",
                "DiskImageSize": 819056640.0,
                "Format": "VMDK",
                "SnapshotId": "snap-06331325870076318",
                "Status": "completed",
                "UserBucket": {
                    "S3Bucket": "external-images",
                    "S3Key": "rhcos-4.7.0-x86_64-aws.x86_64.vmdk"
                }
            }
        }
    ]
}
```

Copy the **SnapshotId** to register the image.

8. Create a custom RHCOS AMI from the RHCOS snapshot:

```
$ aws ec2 register-image \
  --region ${AWS_DEFAULT_REGION} \
  --architecture x86_64 \ 1
  --description "rhcos-${RHCOS_VERSION}-x86_64-aws.x86_64" \ 2
  --ena-support \
  --name "rhcos-${RHCOS_VERSION}-x86_64-aws.x86_64" \ 3
  --virtualization-type hvm \
  --root-device-name '/dev/xvda' \
  --block-device-mappings 'DeviceName=/dev/xvda,Ebs=
{DeleteOnTermination=true,SnapshotId=<snapshot_ID>}' 4
```

1. The RHCOS VMDK architecture type, like **x86_64**, **aarch64**, **s390x**, or **ppc64le**.
2. The **Description** from the imported snapshot.
3. The name of the RHCOS AMI.
4. The **SnapshotID** from the imported snapshot.

To learn more about these APIs, see the AWS documentation for importing snapshots and creating EBS-backed AMIs.

5.12.8. Obtaining the installation program

Before you install OpenShift Container Platform, download the installation file on a local computer.

Prerequisites

- You have a computer that runs Linux or macOS, with 500 MB of local disk space.

Procedure

1. Access the Infrastructure Provider page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program that corresponds with your host operating system and architecture, and place the file in the directory where you will store the installation configuration files.

IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.

IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation pull secret from the Red Hat OpenShift Cluster Manager . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

5.12.9. Manually creating the installation configuration file

Installing the cluster requires that you manually generate the installation configuration file.

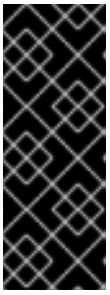
Prerequisites

- You have uploaded a custom RHCOS AMI.
- You have an SSH public key on your local machine to provide to the installation program. The key will be used for SSH authentication onto your cluster nodes for debugging and disaster recovery.
- You have obtained the OpenShift Container Platform installation program and the pull secret for your cluster.

Procedure

1. Create an installation directory to store your required installation assets in:

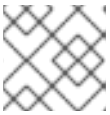
```
$ mkdir <installation_directory>
```



IMPORTANT

You must create a directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

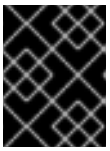
2. Customize the sample **install-config.yaml** file template that is provided and save it in the **<installation_directory>**.



NOTE

You must name this configuration file **install-config.yaml**.

3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.



IMPORTANT

The **install-config.yaml** file is consumed during the next step of the installation process. You must back it up now.

5.12.9.1. Installation configuration parameters

Before you deploy an OpenShift Container Platform cluster, you provide parameter values to describe your account on the cloud platform that hosts your cluster and optionally customize your cluster's platform. When you create the **install-config.yaml** installation configuration file, you provide values for the required parameters through the command line. If you customize your cluster, you can modify the **install-config.yaml** file to provide more details about the platform.

NOTE

After installation, you cannot modify these parameters in the **install-config.yaml** file.

5.12.9.1.1. Required configuration parameters

Required installation configuration parameters are described in the following table:

Table 5.42. Required parameters

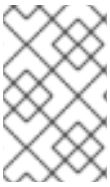
Parameter	Description	Values
apiVersion	The API version for the **install-config.yaml** content. The current version is **v1**. The installer may also support older API versions.	String

Parameter	Description	Values
baseDomain	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the **baseDomain** and **metadata.name** parameter values that uses the **<metadata.name>.<baseDomain>** format.	A fully-qualified domain or subdomain name, such as **example.com**.
metadata	Kubernetes resource **ObjectMeta**, from which only the **name** parameter is consumed.	Object
metadata.name	The name of the cluster. DNS records for the cluster are all subdomains of **{{.metadata.name}}.{{.baseDomain}}**.	String of lowercase letters, hyphens (**-**), and periods (**.**), such as **dev**.
platform	The configuration for the specific platform upon which to perform the installation: **alibabacloud**, **aws**, **baremetal**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**. For additional information about **platform.<platform>** parameters, consult the table for your specific platform that follows.	Object
pullSecret	Get a pull secret from the Red Hat OpenShift Cluster Manager to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	{ "auths":{ "cloud.openshift.com":{ "auth":"b3Blb=", "email":"you@example.com" }, "quay.io":{ "auth":"b3Blb=", "email":"you@example.com" } } }

5.12.9.1.2. Network configuration parameters

You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

Only IPv4 addresses are supported.



NOTE

Globalnet is not supported with Red Hat OpenShift Data Foundation disaster recovery solutions. For regional disaster recovery scenarios, ensure that you use a nonoverlapping range of private IP addresses for the cluster and service networks in each cluster.

Table 5.43. Network parameters

Parameter	Description	Values
networking	The configuration for the cluster network.	Object **NOTE** You cannot modify parameters specified by the **networking** object after installation.
networking.networkType	The cluster network provider Container Network Interface (CNI) cluster network provider to install.	Either **OpenShiftSDN** or **OVNKubernetes**. **OpenShiftSDN** is a CNI provider for all-Linux networks. **OVNKubernetes** is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is **OpenShiftSDN**.
networking.clusterNetwork	The IP address blocks for pods. The default value is **10.128.0.0/14** with a host prefix of **/23**. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: `networking:` `  clusterNetwork:` `  - cidr: 10.128.0.0/14` `  hostPrefix: 23`
networking.clusterNetwork.cidr	Required if you use **networking.clusterNetwork**. An IP address block. An IPv4 network.	An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between **0** and **32**.

Parameter	Description	Values
networking.clusterNetwork.hostPrefix	The subnet prefix length to assign to each individual node. For example, if **hostPrefix** is set to **23** then each node is assigned a /**23** subnet out of the given **cidr**. A **hostPrefix** value of **23** provides 510 (2^(32 - 23) - 2) pod IP addresses.	A subnet prefix. The default value is **23**.
networking.serviceNetwork	The IP address block for services. The default value is **172.30.0.0/16**. The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.	An array with an IP address block in CIDR format. For example: networking: serviceNetwork: - 172.30.0.0/16
networking.machineNetwork	The IP address blocks for machines. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: networking: machineNetwork: - cidr: 10.0.0.0/16
networking.machineNetwork.cidr	Required if you use **networking.machineNetwork**. An IP address block. The default value is **10.0.0.0/16** for all platforms other than libvirt. For libvirt, the default value is **192.168.126.0/24**.	An IP network block in CIDR notation. For example, **10.0.0.0/16**. **NOTE** Set the **networking.machineNetwork** to match the CIDR that the preferred NIC resides in.

5.12.9.1.3. Optional configuration parameters

Optional installation configuration parameters are described in the following table:

Table 5.44. Optional parameters

Parameter	Description	Values
additionalTrustBundle	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String

Parameter	Description	Values
capabilities	Controls the installation of optional core cluster components. You can reduce the footprint of your OpenShift Container Platform cluster by disabling optional components.	String array
capabilities.baselineCapabilitySet	Selects an initial set of optional capabilities to enable. Valid values are **None**, **v4.11** and **vCurrent**. **v4.11** enables the **baremetal** Operator, the **marketplace** Operator, and the **openshift-samples** content. **vCurrent** installs the recommended set of capabilities for the current version of OpenShift Container Platform. The default value is **vCurrent**.	String
capabilities.additionalEnabledCapabilities	Extends the set of optional capabilities beyond what you specify in **baselineCapabilitySet**. Valid values are **baremetal**, **marketplace** and **openshift-samples**. You may specify multiple capabilities in this parameter.	String array
cgroupsV2	Enables Linux control groups version 2 (cgroups v2) on specific nodes in your cluster. The OpenShift Container Platform process for enabling cgroups v2 disables all cgroup version 1 controllers and hierarchies. The OpenShift Container Platform cgroups version 2 feature is in Developer Preview and is not supported by Red Hat at this time.	**true**
compute	The configuration for the machines that comprise the compute nodes.	Array of **MachinePool** objects.
compute.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** (the default).	String

Parameter	Description	Values
compute.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  IMPORTANT If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
compute.name	Required if you use **compute**. The name of the machine pool.	**worker**
compute.platform	Required if you use **compute**. Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the **controlPlane.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
compute.replicas	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to **2**. The default value is **3**.
controlPlane	The configuration for the machines that comprise the control plane.	Array of **MachinePool** objects.
controlPlane.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** (the default).	String

Parameter	Description	Values
controlPlane.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  **IMPORTANT** If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
controlPlane.name	Required if you use **controlPlane**. The name of the machine pool.	**master**
controlPlane.platform	Required if you use **controlPlane**. Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the **compute.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
controlPlane.replicas	The number of control plane machines to provision.	The only supported value is **3**, which is the default value.

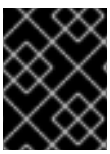
Parameter	Description	Values
credentialsMode	The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported.  **NOTE** Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the *Cloud Credential Operator* entry in the *Cluster Operators reference* content.  **NOTE** If your AWS account has service control policies (SCP) enabled, you must configure the **credentialsMode** parameter to **Mint**, **Passthrough** or **Manual**.	**Mint**, **Passthrough**, **Manual** or an empty string (**""**).

Parameter	Description	Values
fips	Enable or disable FIPS mode. The default is **false** (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.  **IMPORTANT** To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.  **NOTE** If you are using Azure File storage, you cannot enable FIPS mode.	**false** or **true**
imageContentSources	Sources and repositories for the release-image content.	Array of objects. Includes a **source** and, optionally, **mirrors**, as described in the following rows of this table.
imageContentSources.source	Required if you use **imageContentSources**. Specify the repository that users refer to, for example, in image pull specifications.	String

Parameter	Description	Values
imageContentSources.mirrors	Specify one or more repositories that may also contain the same images.	Array of strings
publish	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	**Internal** or **External**. The default value is **External**. Setting this field to **Internal** is not supported on non-cloud platforms and IBM Cloud VPC.  **IMPORTANT** If the value of the field is set to **Internal**, the cluster will become non-functional. For more information, refer to BZ#1953035.
sshKey	The SSH key to authenticate access to your cluster machines.  **NOTE** For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.	For example, **sshKey: ssh-ed25519 AAAA..**.

5.12.9.2. Sample customized install-config.yaml file for AWS

You can customize the installation configuration file (**install-config.yaml**) to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.



IMPORTANT

This sample YAML file is provided for reference only. Use it as a resource to enter parameter values into the installation configuration file that you created manually.

```
apiVersion: v1
baseDomain: example.com (1)
credentialsMode: Mint (2)
controlPlane: (3) (4)
  hyperthreading: Enabled (5)
  name: master
  platform:
    aws:
      zones:
      - cn-north-1a
      - cn-north-1b
      rootVolume:
        iops: 4000
        size: 500
        type: io1 (6)
      metadataService:
        authentication: Optional (7)
      type: m6i.xlarge
  replicas: 3
compute: (8)
- hyperthreading: Enabled (9)
  name: worker
  platform:
    aws:
      rootVolume:
        iops: 2000
        size: 500
        type: io1 (10)
      metadataService:
        authentication: Optional (11)
      type: c5.4xlarge
      zones:
      - cn-north-1a
  replicas: 3
metadata:
  name: test-cluster (12)
networking:
  clusterNetwork:
  - cidr: 10.128.0.0/14
    hostPrefix: 23
  machineNetwork:
  - cidr: 10.0.0.0/16
  networkType: OpenShiftSDN
  serviceNetwork:
  - 172.30.0.0/16
platform:
  aws:
    region: cn-north-1 (13)
    userTags:
      adminContact: jdoe
      costCenter: 7536
    subnets: (14)
    - subnet-1
    - subnet-2
```

```
    - subnet-3
    amiID: ami-96c6f8f7 15 16
    serviceEndpoints: 17
      - name: ec2
        url: https://vpce-id.ec2.cn-north-1.vpce.amazonaws.com.cn
    hostedZone: Z3URY6TWQ91KVV 18
fips: false 19
sshKey: ssh-ed25519 AAAA... 20
publish: Internal 21
pullSecret: '{"auths": ...}' 22
```

1 12 13 15 22 Required.

2 Optional: Add this parameter to force the Cloud Credential Operator (CCO) to use the specified mode, instead of having the CCO dynamically try to determine the capabilities of the credentials. For details about CCO modes, see the *Cloud Credential Operator* entry in the *Red Hat Operators reference* content.

3 8 If you do not provide these parameters and values, the installation program provides the default value.

4 The **controlPlane** section is a single mapping, but the **compute** section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, **-**, and the first line of the **controlPlane** section must not. Only one control plane pool is used.

5 9 Whether to enable or disable simultaneous multithreading, or **hyperthreading**. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores. You can disable it by setting the parameter value to **Disabled**. If you disable simultaneous multithreading in some cluster machines, you must disable it in all cluster machines.

IMPORTANT

If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance. Use larger instance types, such as **m4.2xlarge** or **m5.2xlarge**, for your machines if you disable simultaneous multithreading.

6 10 To configure faster storage for etcd, especially for larger clusters, set the storage type as **io1** and set **iops** to **2000**.

7 11 Whether to require the Amazon EC2 Instance Metadata Service v2 (IMDSv2). To require IMDSv2, set the parameter value to **Required**. To allow the use of both IMDSv1 and IMDSv2, set the parameter value to **Optional**. If no value is specified, both IMDSv1 and IMDSv2 are allowed.

NOTE

The IMDS configuration for control plane machines that is set during cluster installation can only be changed by using the AWS CLI. The IMDS configuration for compute machines can be changed by using machine sets.

14 If you provide your own VPC, specify subnets for each availability zone that your cluster uses.

16 The ID of the AMI used to boot machines for the cluster. If set, the AMI must belong to the same

17 The AWS service endpoints. Custom endpoints are required when installing to an unknown AWS region. The endpoint URL must use the **https** protocol and the host must trust the certificate.

18 The ID of your existing Route 53 private hosted zone. Providing an existing hosted zone requires that you supply your own VPC and the hosted zone is already associated with the VPC prior to installing your cluster. If undefined, the installation program creates a new hosted zone.

19 Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.

IMPORTANT

To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.

20 You can optionally provide the **sshKey** value that you use to access the machines in your cluster.

NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

21 How to publish the user-facing endpoints of your cluster. Set **publish** to **Internal** to deploy a private cluster, which cannot be accessed from the internet. The default value is **External**.

5.12.9.3. Minimum resource requirements for cluster installation

Each cluster machine must meet the following minimum requirements:

Table 5.45. Minimum resource requirements

Machine	Operating System	vCPU [1]	Virtual RAM	Storage	IOPS [2]
Bootstrap	RHCOS	4	16 GB	100 GB	300
Control plane	RHCOS	4	16 GB	100 GB	300
Compute	RHCOS, RHEL 8.6 and later [3]	2	8 GB	100 GB	300

1. One vCPU is equivalent to one physical core when simultaneous multithreading (SMT), or hyperthreading, is not enabled. When enabled, use the following formula to calculate the corresponding ratio: (threads per core × cores) × sockets = vCPUs.

2. OpenShift Container Platform and Kubernetes are sensitive to disk performance, and faster storage is recommended, particularly for etcd on the control plane nodes which require a 10 ms p99 fsync duration. Note that on many cloud platforms, storage size and IOPS scale together, so you might need to over-allocate storage volume to obtain sufficient performance.

3. As with all user-provisioned installations, if you choose to use RHEL compute machines in your cluster, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks. Use of RHEL 7 compute machines is deprecated and has been removed in OpenShift Container Platform 4.10 and later.

If an instance type for your platform meets the minimum requirements for cluster machines, it is supported to use in OpenShift Container Platform.

Additional resources

- Optimizing storage

5.12.9.4. Tested instance types for AWS

The following Amazon Web Services (AWS) instance types have been tested with OpenShift Container Platform.

NOTE

Use the machine types included in the following charts for your AWS instances. If you use an instance type that is not listed in the chart, ensure that the instance size you use matches the minimum resource requirements that are listed in "Minimum resource requirements for cluster installation".

Example 5.27. Machine types based on 64-bit x86 architecture

- **c4.***
- **c5.***
- **c5a.***
- **i3.***
- **m4.***
- **m5.***
- **m5a.***
- **m6a.***
- **m6i.***
- **r4.***

- **r5.***
- **r5a.***
- **r6i.***
- **t3.***
- **t3a.***

5.12.9.5. Tested instance types for AWS on 64-bit ARM infrastructures

The following Amazon Web Services (AWS) ARM64 instance types have been tested with OpenShift Container Platform.

NOTE

Use the machine types included in the following charts for your AWS ARM instances. If you use an instance type that is not listed in the chart, ensure that the instance size you use matches the minimum resource requirements that are listed in "Minimum resource requirements for cluster installation".

Example 5.28. Machine types based on 64-bit ARM architecture

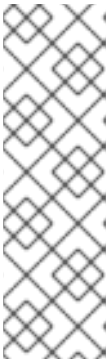
- **c6g.***
- **m6g.***

5.12.9.6. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.



NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: ec2.<region>.amazonaws.com,elasticloadbalancing.
<region>.amazonaws.com,s3.<region>.amazonaws.com 3
additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
```

1. A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.

2. A proxy URL to use for creating HTTPS connections outside the cluster.

3. A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use ***** to bypass the proxy for all destinations. If you have added the Amazon **EC2**,**Elastic Load Balancing**, and **S3** VPC endpoints to your VPC, you must add these endpoints to the **noProxy** field.

4. If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace that contains one or more additional CA certificates that are required for proxying HTTPS connections. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges these contents with the Red Hat Enterprise Linux CoreOS (RHCOS) trust bundle, and this config map is referenced in the **trustedCA** field of the **Proxy** object. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.

NOTE

The installation program does not support the proxy **readinessEndpoints** field.

NOTE

If the installer times out, restart and then complete the deployment by using the **wait-for** command of the installer. For example:

```
$ ./openshift-install wait-for install-complete --log-level debug
```

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.

NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

5.12.10. Deploying the cluster

You can install OpenShift Container Platform on a compatible cloud platform.

IMPORTANT

You can run the **create cluster** command of the installation program only once, during initial installation.

Prerequisites

- Configure an account with the cloud platform that hosts your cluster.
- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.

Procedure

1. Change to the directory that contains the installation program and initialize the cluster deployment:

```
$ ./openshift-install create cluster --dir <installation_directory> \ 1
    --log-level=info 2
```

1 For **<installation_directory>**, specify the location of your customized **./install-config.yaml** file.

2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

NOTE

If the cloud provider account that you configured on your host does not have sufficient permissions to deploy the cluster, the installation process stops, and the missing permissions are displayed.

2. Optional: Remove or disable the **AdministratorAccess** policy from the IAM account that you used to install the cluster.

NOTE

The elevated permissions provided by the **AdministratorAccess** policy are required only during installation.

Verification

When the cluster deployment completes successfully:

- The terminal displays directions for accessing your cluster, including a link to the web console and credentials for the **kubeadmin** user.
- Credential information also outputs to **<installation_directory>/.openshift_install.log**.

IMPORTANT

Do not delete the installation program or the files that the installation program creates. Both are required to delete the cluster.

Example output

```
...
INFO Install complete!
INFO To access the cluster as the system:admin user when using 'oc', run 'export
KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
INFO Access the OpenShift web-console here: https://console-openshift-
console.apps.mycluster.example.com
INFO Login to the console with user: "kubeadmin", and password: "password"
INFO Time elapsed: 36m22s
```

IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

5.12.11. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.

IMPORTANT

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.11. Download and install the new version of **oc**.

Installing the OpenShift CLI on Linux

You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the architecture in the **Product Variant** drop-down menu.
3. Select the appropriate version in the **Version** drop-down menu.
4. Click **Download Now** next to the **OpenShift v4.11 Linux Client** entry and save the file.
5. Unpack the archive:

```
$ tar xvf <file>
```

6. Place the **oc** binary in a directory that is on your **PATH**.
   To check your **PATH**, execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.
   To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
C:\> oc <command>
```

Installing the OpenShift CLI on macOS
You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 macOS Client** entry and save the file.

NOTE

For macOS arm64, choose the **OpenShift v4.11 macOS arm64 Client** entry.

4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your PATH.
   To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

5.12.12. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

Example output

```
system:admin
```

5.12.13. Logging in to the cluster by using the web console

The **kubeadmin** user exists by default after an OpenShift Container Platform installation. You can log in to your cluster as the **kubeadmin** user by using the OpenShift Container Platform web console.

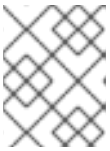
Prerequisites

- You have access to the installation host.
- You completed a cluster installation and all cluster Operators are available.

Procedure

1. Obtain the password for the **kubeadmin** user from the **kubeadmin-password** file on the installation host:

```
$ cat <installation_directory>/auth/kubeadmin-password
```



NOTE

Alternatively, you can obtain the **kubeadmin** password from the **<installation_directory>/.openshift_install.log** log file on the installation host.

2. List the OpenShift Container Platform web console route:

```
$ oc get routes -n openshift-console | grep 'console-openshift'
```

NOTE

Alternatively, you can obtain the OpenShift Container Platform route from the **<installation_directory>/.openshift_install.log** log file on the installation host.

Example output

```
console     console-openshift-console.apps.<cluster_name>.<base_domain>           console
https   reencrypt/Redirect   None
```

3. Navigate to the route detailed in the output of the preceding command in a web browser and log in as the **kubeadmin** user.

5.12.14. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.11, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to OpenShift Cluster Manager Hybrid Cloud Console.

After you confirm that your OpenShift Cluster Manager Hybrid Cloud Console inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, use subscription watch to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

Additional resources

- See Accessing the web console for more details about accessing and understanding the OpenShift Container Platform web console.
- See About remote health monitoring for more information about the Telemetry service.

5.12.15. Next steps

- Validating an installation.
- Customize your cluster.
- If necessary, you can opt out of remote health reporting .
- If necessary, you can remove cloud provider credentials.

5.13. INSTALLING A CLUSTER ON USER-PROVISIONED INFRASTRUCTURE IN AWS BY USING CLOUDFORMATION TEMPLATES

In OpenShift Container Platform version 4.11, you can install a cluster on Amazon Web Services (AWS) that uses infrastructure that you provide.

One way to create this infrastructure is to use the provided CloudFormation templates. You can modify the templates to customize your infrastructure or use the information that they contain to create AWS objects according to your company's policies.

IMPORTANT

The steps for performing a user-provisioned infrastructure installation are provided as an example only. Installing a cluster with infrastructure you provide requires knowledge of the cloud provider and the installation process of OpenShift Container Platform. Several CloudFormation templates are provided to assist in completing these steps or to help model your own. You are also free to create the required resources through other methods; the templates are just an example.

5.13.1. Prerequisites

- You reviewed details about the OpenShift Container Platform installation and update processes.
- You read the documentation on selecting a cluster installation method and preparing it for users.
- You configured an AWS account to host the cluster.

IMPORTANT

If you have an AWS profile stored on your computer, it must not use a temporary session token that you generated while using a multi-factor authentication device. The cluster continues to use your current AWS credentials to create AWS resources for the entire life of the cluster, so you must use key-based, long-lived credentials. To generate appropriate keys, see Managing Access Keys for IAM Users in the AWS documentation. You can supply the keys when you run the installation program.

- You downloaded the AWS CLI and installed it on your computer. See Install the AWS CLI Using the Bundled Installer (Linux, macOS, or UNIX) in the AWS documentation.
- If you use a firewall, you configured it to allow the sites that your cluster requires access to.

NOTE

Be sure to also review this site list if you are configuring a proxy.

- If the cloud identity and access management (IAM) APIs are not accessible in your environment, or if you do not want to store an administrator-level credential secret in the **kube-system** namespace, you can manually create and maintain IAM credentials.

5.13.2. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.11, you require access to the internet to install your cluster.

You must have internet access to:

- Access OpenShift Cluster Manager Hybrid Cloud Console to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access Quay.io to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.

IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

5.13.3. Requirements for a cluster with user-provisioned infrastructure

For a cluster that contains user-provisioned infrastructure, you must deploy all of the required machines.

This section describes the requirements for deploying OpenShift Container Platform on user-provisioned infrastructure.

5.13.3.1. Required machines for cluster installation

The smallest OpenShift Container Platform clusters require the following hosts:

Table 5.46. Minimum required hosts

Hosts	Description
One temporary bootstrap machine	The cluster requires the bootstrap machine to deploy the OpenShift Container Platform cluster on the three control plane machines. You can remove the bootstrap machine after you install the cluster.
Three control plane machines	The control plane machines run the Kubernetes and OpenShift Container Platform services that form the control plane.
At least two compute machines, which are also known as worker machines.	The workloads requested by OpenShift Container Platform users run on the compute machines.

IMPORTANT

To maintain high availability of your cluster, use separate physical hosts for these cluster machines.

The bootstrap and control plane machines must use Red Hat Enterprise Linux CoreOS (RHCOS) as the operating system. However, the compute machines can choose between Red Hat Enterprise Linux CoreOS (RHCOS), Red Hat Enterprise Linux (RHEL) 8.6 and later.

Note that RHCOS is based on Red Hat Enterprise Linux (RHEL) 8 and inherits all of its hardware certifications and requirements. See Red Hat Enterprise Linux technology capabilities and limits .

5.13.3.2. Minimum resource requirements for cluster installation

Each cluster machine must meet the following minimum requirements:

Table 5.47. Minimum resource requirements

Machine	Operating System	vCPU [1]	Virtual RAM	Storage	IOPS [2]
Bootstrap	RHCOS	4	16 GB	100 GB	300
Control plane	RHCOS	4	16 GB	100 GB	300

Machine	Operating System	vCPU [1]	Virtual RAM	Storage	IOPS [2]
Compute	RHCOS, RHEL 8.6 and later [3]	2	8 GB	100 GB	300

1. One vCPU is equivalent to one physical core when simultaneous multithreading (SMT), or hyperthreading, is not enabled. When enabled, use the following formula to calculate the corresponding ratio: (threads per core × cores) × sockets = vCPUs.

2. OpenShift Container Platform and Kubernetes are sensitive to disk performance, and faster storage is recommended, particularly for etcd on the control plane nodes which require a 10 ms p99 fsync duration. Note that on many cloud platforms, storage size and IOPS scale together, so you might need to over-allocate storage volume to obtain sufficient performance.

3. As with all user-provisioned installations, if you choose to use RHEL compute machines in your cluster, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks. Use of RHEL 7 compute machines is deprecated and has been removed in OpenShift Container Platform 4.10 and later.

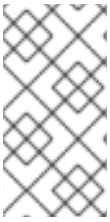
If an instance type for your platform meets the minimum requirements for cluster machines, it is supported to use in OpenShift Container Platform.

Additional resources

- Optimizing storage

5.13.3.3. Tested instance types for AWS

The following Amazon Web Services (AWS) instance types have been tested with OpenShift Container Platform.



NOTE

Use the machine types included in the following charts for your AWS instances. If you use an instance type that is not listed in the chart, ensure that the instance size you use matches the minimum resource requirements that are listed in "Minimum resource requirements for cluster installation".

Example 5.29. Machine types based on 64-bit x86 architecture

- **c4.***
- **c5.***
- **c5a.***
- **i3.***
- **m4.***

- **m5.***
- **m5a.***
- **m6a.***
- **m6i.***
- **r4.***
- **r5.***
- **r5a.***
- **r6i.***
- **t3.***
- **t3a.***

5.13.3.4. Tested instance types for AWS on 64-bit ARM infrastructures

The following Amazon Web Services (AWS) ARM64 instance types have been tested with OpenShift Container Platform.

NOTE

Use the machine types included in the following charts for your AWS ARM instances. If you use an instance type that is not listed in the chart, ensure that the instance size you use matches the minimum resource requirements that are listed in "Minimum resource requirements for cluster installation".

Example 5.30. Machine types based on 64-bit ARM architecture

- **c6g.***
- **m6g.***

5.13.3.5. Certificate signing requests management

Because your cluster has limited access to automatic machine management when you use infrastructure that you provision, you must provide a mechanism for approving cluster certificate signing requests (CSRs) after installation. The **kube-controller-manager** only approves the kubelet client CSRs. The **machine-approver** cannot guarantee the validity of a serving certificate that is requested by using kubelet credentials because it cannot confirm that the correct machine issued the request. You must determine and implement a method of verifying the validity of the kubelet serving certificate requests and approving them.

5.13.4. Required AWS infrastructure components

To install OpenShift Container Platform on user-provisioned infrastructure in Amazon Web Services (AWS), you must manually create both the machines and their supporting infrastructure.

For more information about the integration testing for different platforms, see the OpenShift Container Platform 4.x Tested Integrations page.

By using the provided CloudFormation templates, you can create stacks of AWS resources that represent the following components:

- An AWS Virtual Private Cloud (VPC)
- Networking and load balancing components
- Security groups and roles
- An OpenShift Container Platform bootstrap node
- OpenShift Container Platform control plane nodes
- An OpenShift Container Platform compute node

Alternatively, you can manually create the components or you can reuse existing infrastructure that meets the cluster requirements. Review the CloudFormation templates for more details about how the components interrelate.

5.13.4.1. Other infrastructure components

- A VPC
- DNS entries
- Load balancers (classic or network) and listeners
- A public and a private Route 53 zone
- Security groups
- IAM roles
- S3 buckets

If you are working in a disconnected environment, you are unable to reach the public IP addresses for EC2, ELB, and S3 endpoints. Depending on the level to which you want to restrict internet traffic during the installation, the following configuration options are available:

Option 1: Create VPC endpoints
Create a VPC endpoint and attach it to the subnets that the clusters are using. Name the endpoints as follows:

- **ec2.<region>.amazonaws.com**
- **elasticloadbalancing.<region>.amazonaws.com**
- **s3.<region>.amazonaws.com**

With this option, network traffic remains private between your VPC and the required AWS services.

Option 2: Create a proxy without VPC endpoints
As part of the installation process, you can configure an HTTP or HTTPS proxy. With this option, internet traffic goes through the proxy to reach the required AWS services.

Option 3: Create a proxy with VPC endpoints
As part of the installation process, you can configure an HTTP or HTTPS proxy with VPC endpoints. Create a VPC endpoint and attach it to the subnets that the clusters are using. Name the endpoints as follows:

- **ec2.<region>.amazonaws.com**
- **elasticloadbalancing.<region>.amazonaws.com**
- **s3.<region>.amazonaws.com**

When configuring the proxy in the **install-config.yaml** file, add these endpoints to the **noProxy** field. With this option, the proxy prevents the cluster from accessing the internet directly. However, network traffic remains private between your VPC and the required AWS services.

Required VPC components

You must provide a suitable VPC and subnets that allow communication to your machines.

Component	AWS type	Description
VPC	• **AWS::EC2::VPC** • **AWS::EC2::VPCEndpoint**	You must provide a public VPC for the cluster to use. The VPC uses an endpoint that references the route tables for each subnet to improve communication with the registry that is hosted in S3.
Public subnets	• **AWS::EC2::Subnet** • **AWS::EC2::SubnetNetworkAclAssociation**	Your VPC must have public subnets for between 1 and 3 availability zones and associate them with appropriate Ingress rules.
Internet gateway	• **AWS::EC2::InternetGateway** • **AWS::EC2::VPCGatewayAttachment** • **AWS::EC2::RouteTable** • **AWS::EC2::Route** • **AWS::EC2::SubnetRouteTableAssociation** • **AWS::EC2::NatGateway** • **AWS::EC2::EIP**	You must have a public internet gateway, with public routes, attached to the VPC. In the provided templates, each public subnet has a NAT gateway with an EIP address. These NAT gateways allow cluster resources, like private subnet instances, to reach the internet and are not required for some restricted network or proxy scenarios.
Network access control	• **AWS::EC2::NetworkAcl** • **AWS::EC2::NetworkAclEntry**	You must allow the VPC to access the following ports: **Port** / **Reason**

Component	AWS type	Description	
		80	Inbound HTTP traffic
		443	Inbound HTTPS traffic
		22	Inbound SSH traffic
		1024 - 65535	Inbound ephemeral traffic
		0 - 65535	Outbound ephemeral traffic
Private subnets	• **AWS::EC2::Subnet** • **AWS::EC2::RouteTable** • **AWS::EC2::SubnetRouteTableAssociation**	Your VPC can have private subnets. The provided CloudFormation templates can create private subnets for between 1 and 3 availability zones. If you use private subnets, you must provide appropriate routes and tables for them.	

Required DNS and load balancing components

Your DNS and load balancer configuration needs to use a public hosted zone and can use a private hosted zone similar to the one that the installation program uses if it provisions the cluster's infrastructure. You must create a DNS entry that resolves to your load balancer. An entry for **api.<cluster_name>.<domain>** must point to the external load balancer, and an entry for **api-int.<cluster_name>.<domain>** must point to the internal load balancer.

The cluster also requires load balancers and listeners for port 6443, which are required for the Kubernetes API and its extensions, and port 22623, which are required for the Ignition config files for new machines. The targets will be the control plane nodes. Port 6443 must be accessible to both clients external to the cluster and nodes within the cluster. Port 22623 must be accessible to nodes within the cluster.

Component	AWS type	Description
DNS	**AWS::Route53::HostedZone**	The hosted zone for your internal DNS.
Public load balancer	**AWS::ElasticLoadBalancingV2::LoadBalancer**	The load balancer for your public subnets.

Component	AWS type	Description
External API server record	**AWS::Route53::RecordSetGroup**	Alias records for the external API server.
External listener	**AWS::ElasticLoadBalancingV2::Listener**	A listener on port 6443 for the external load balancer.
External target group	**AWS::ElasticLoadBalancingV2::TargetGroup**	The target group for the external load balancer.
Private load balancer	**AWS::ElasticLoadBalancingV2::LoadBalancer**	The load balancer for your private subnets.
Internal API server record	**AWS::Route53::RecordSetGroup**	Alias records for the internal API server.
Internal listener	**AWS::ElasticLoadBalancingV2::Listener**	A listener on port 22623 for the internal load balancer.
Internal target group	**AWS::ElasticLoadBalancingV2::TargetGroup**	The target group for the internal load balancer.
Internal listener	**AWS::ElasticLoadBalancingV2::Listener**	A listener on port 6443 for the internal load balancer.
Internal target group	**AWS::ElasticLoadBalancingV2::TargetGroup**	The target group for the internal load balancer.

Security groups

The control plane and worker machines require access to the following ports:

Group	Type	IP Protocol	Port range
MasterSecurityGroup	**AWS::EC2::SecurityGroup**	**icmp**	**0**
		tcp	**22**
		tcp	**6443**
		tcp	**22623**
WorkerSecurityGroup	**AWS::EC2::SecurityGroup**	**icmp**	**0**
		tcp	**22**
BootstrapSecurityGroup	**AWS::EC2::SecurityGroup**	**tcp**	**22**
		tcp	**19531**

Control plane Ingress

The control plane machines require the following Ingress groups. Each Ingress group is a **AWS::EC2::SecurityGroupIngress** resource.

Ingress group	Description	IP protocol	Port range
MasterIngressEtcd	etcd	**tcp**	**2379- 2380**
MasterIngressVxlan	Vxlan packets	**udp**	**4789**
MasterIngressWorkerVxlan	Vxlan packets	**udp**	**4789**
MasterIngressInternal	Internal cluster communication and Kubernetes proxy metrics	**tcp**	**9000 - 9999**
MasterIngressWorkerInternal	Internal cluster communication	**tcp**	**9000 - 9999**
MasterIngressKube	Kubernetes kubelet, scheduler and controller manager	**tcp**	**10250 - 10259**
MasterIngressWorkerKube	Kubernetes kubelet, scheduler and controller manager	**tcp**	**10250 - 10259**

Ingress group	Description	IP protocol	Port range
MasterIngressIngressServices	Kubernetes Ingress services	**tcp**	**30000 - 32767**
MasterIngressWorkerIngressServices	Kubernetes Ingress services	**tcp**	**30000 - 32767**
MasterIngressGeneve	Geneve packets	**udp**	**6081**
MasterIngressWorkerGeneve	Geneve packets	**udp**	**6081**
MasterIngressIpsecIke	IPsec IKE packets	**udp**	**500**
MasterIngressWorkerIpsecIke	IPsec IKE packets	**udp**	**500**
MasterIngressIpsecNat	IPsec NAT-T packets	**udp**	**4500**
MasterIngressWorkerIpsecNat	IPsec NAT-T packets	**udp**	**4500**
MasterIngressIpsecEsp	IPsec ESP packets	**50**	**All**
MasterIngressWorkerIpsecEsp	IPsec ESP packets	**50**	**All**
MasterIngressInternalUDP	Internal cluster communication	**udp**	**9000 - 9999**
MasterIngressWorkerInternalUDP	Internal cluster communication	**udp**	**9000 - 9999**
MasterIngressIngressServicesUDP	Kubernetes Ingress services	**udp**	**30000 - 32767**

Ingress group	Description	IP protocol	Port range
MasterIngressWorkerIngressServicesUDP	Kubernetes Ingress services	**udp**	**30000 - 32767**

Worker Ingress

The worker machines require the following Ingress groups. Each Ingress group is a **AWS::EC2::SecurityGroupIngress** resource.

Ingress group	Description	IP protocol	Port range
WorkerIngressVxlan	Vxlan packets	**udp**	**4789**
WorkerIngressWorkerVxlan	Vxlan packets	**udp**	**4789**
WorkerIngressInternal	Internal cluster communication	**tcp**	**9000 - 9999**
WorkerIngressWorkerInternal	Internal cluster communication	**tcp**	**9000 - 9999**
WorkerIngressKube	Kubernetes kubelet, scheduler, and controller manager	**tcp**	**10250**
WorkerIngressWorkerKube	Kubernetes kubelet, scheduler, and controller manager	**tcp**	**10250**
WorkerIngressIngressServices	Kubernetes Ingress services	**tcp**	**30000 - 32767**
WorkerIngressWorkerIngressServices	Kubernetes Ingress services	**tcp**	**30000 - 32767**
WorkerIngressGeneve	Geneve packets	**udp**	**6081**
WorkerIngressMasterGeneve	Geneve packets	**udp**	**6081**
WorkerIngressIpsecIke	IPsec IKE packets	**udp**	**500**

Ingress group	Description	IP protocol	Port range
WorkerIngressMasterIpsecIke	IPsec IKE packets	**udp**	**500**
WorkerIngressIpsecNat	IPsec NAT-T packets	**udp**	**4500**
WorkerIngressMasterIpsecNat	IPsec NAT-T packets	**udp**	**4500**
WorkerIngressIpsecEsp	IPsec ESP packets	**50**	**All**
WorkerIngressMasterIpsecEsp	IPsec ESP packets	**50**	**All**
WorkerIngressInternalUDP	Internal cluster communication	**udp**	**9000 - 9999**
WorkerIngressMasterInternalUDP	Internal cluster communication	**udp**	**9000 - 9999**
WorkerIngressIngressServicesUDP	Kubernetes Ingress services	**udp**	**30000 - 32767**
WorkerIngressMasterIngressServicesUDP	Kubernetes Ingress services	**udp**	**30000 - 32767**

Roles and instance profiles

You must grant the machines permissions in AWS. The provided CloudFormation templates grant the machines **Allow** permissions for the following **AWS::IAM::Role** objects and provide a **AWS::IAM::InstanceProfile** for each set of roles. If you do not use the templates, you can grant the machines the following broad permissions or the following individual permissions.

Role	Effect	Action	Resource
Master	**Allow**	**ec2:***	*
	Allow	**elasticloadbalancing:***	*

Role	Effect	Action	Resource
	Allow	**iam:PassRole**	*
	Allow	**s3:GetObject**	*
Worker	**Allow**	**ec2:Describe***	*
Bootstrap	**Allow**	**ec2:Describe***	*
	Allow	**ec2:AttachVolume**	*
	Allow	**ec2:DetachVolume**	*

5.13.4.2. Cluster machines

You need **AWS::EC2::Instance** objects for the following machines:

- A bootstrap machine. This machine is required during installation, but you can remove it after your cluster deploys.
- Three control plane machines. The control plane machines are not governed by a machine set.
- Compute machines. You must create at least two compute machines, which are also known as worker machines, during installation. These machines are not governed by a machine set.

5.13.4.3. Required AWS permissions for the IAM user

NOTE

Your IAM user must have the permission **tag:GetResources** in the region **us-east-1** to delete the base cluster resources. As part of the AWS API requirement, the OpenShift Container Platform installation program performs various actions in this region.

When you attach the **AdministratorAccess** policy to the IAM user that you create in Amazon Web Services (AWS), you grant that user all of the required permissions. To deploy all components of an OpenShift Container Platform cluster, the IAM user requires the following permissions:

Example 5.31. Required EC2 permissions for installation

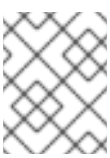
- **ec2:AuthorizeSecurityGroupEgress**
- **ec2:AuthorizeSecurityGroupIngress**
- **ec2:CopyImage**
- **ec2:CreateNetworkInterface**
- **ec2:AttachNetworkInterface**
- **ec2:CreateSecurityGroup**

- **ec2:CreateTags**
- **ec2:CreateVolume**
- **ec2:DeleteSecurityGroup**
- **ec2:DeleteSnapshot**
- **ec2:DeleteTags**
- **ec2:DeregisterImage**
- **ec2:DescribeAccountAttributes**
- **ec2:DescribeAddresses**
- **ec2:DescribeAvailabilityZones**
- **ec2:DescribeDhcpOptions**
- **ec2:DescribeImages**
- **ec2:DescribeInstanceAttribute**
- **ec2:DescribeInstanceCreditSpecifications**
- **ec2:DescribeInstances**
- **ec2:DescribeInstanceTypes**
- **ec2:DescribeInternetGateways**
- **ec2:DescribeKeyPairs**
- **ec2:DescribeNatGateways**
- **ec2:DescribeNetworkAcls**
- **ec2:DescribeNetworkInterfaces**
- **ec2:DescribePrefixLists**
- **ec2:DescribeRegions**
- **ec2:DescribeRouteTables**
- **ec2:DescribeSecurityGroups**
- **ec2:DescribeSubnets**
- **ec2:DescribeTags**
- **ec2:DescribeVolumes**
- **ec2:DescribeVpcAttribute**
- **ec2:DescribeVpcClassicLink**

- **ec2:DescribeVpcClassicLinkDnsSupport**
- **ec2:DescribeVpcEndpoints**
- **ec2:DescribeVpcs**
- **ec2:GetEbsDefaultKmsKeyId**
- **ec2:ModifyInstanceAttribute**
- **ec2:ModifyNetworkInterfaceAttribute**
- **ec2:RevokeSecurityGroupEgress**
- **ec2:RevokeSecurityGroupIngress**
- **ec2:RunInstances**
- **ec2:TerminateInstances**

Example 5.32. Required permissions for creating network resources during installation

- **ec2:AllocateAddress**
- **ec2:AssociateAddress**
- **ec2:AssociateDhcpOptions**
- **ec2:AssociateRouteTable**
- **ec2:AttachInternetGateway**
- **ec2:CreateDhcpOptions**
- **ec2:CreateInternetGateway**
- **ec2:CreateNatGateway**
- **ec2:CreateRoute**
- **ec2:CreateRouteTable**
- **ec2:CreateSubnet**
- **ec2:CreateVpc**
- **ec2:CreateVpcEndpoint**
- **ec2:ModifySubnetAttribute**
- **ec2:ModifyVpcAttribute**



NOTE

If you use an existing VPC, your account does not require these permissions for creating network resources.

Example 5.33. Required Elastic Load Balancing permissions (ELB) for installation

- **elasticloadbalancing:AddTags**
- **elasticloadbalancing:ApplySecurityGroupsToLoadBalancer**
- **elasticloadbalancing:AttachLoadBalancerToSubnets**
- **elasticloadbalancing:ConfigureHealthCheck**
- **elasticloadbalancing:CreateLoadBalancer**
- **elasticloadbalancing:CreateLoadBalancerListeners**
- **elasticloadbalancing:DeleteLoadBalancer**
- **elasticloadbalancing:DeregisterInstancesFromLoadBalancer**
- **elasticloadbalancing:DescribeInstanceHealth**
- **elasticloadbalancing:DescribeLoadBalancerAttributes**
- **elasticloadbalancing:DescribeLoadBalancers**
- **elasticloadbalancing:DescribeTags**
- **elasticloadbalancing:ModifyLoadBalancerAttributes**
- **elasticloadbalancing:RegisterInstancesWithLoadBalancer**
- **elasticloadbalancing:SetLoadBalancerPoliciesOfListener**

Example 5.34. Required Elastic Load Balancing permissions (ELBv2) for installation

- **elasticloadbalancing:AddTags**
- **elasticloadbalancing:CreateListener**
- **elasticloadbalancing:CreateLoadBalancer**
- **elasticloadbalancing:CreateTargetGroup**
- **elasticloadbalancing:DeleteLoadBalancer**
- **elasticloadbalancing:DeregisterTargets**
- **elasticloadbalancing:DescribeListeners**
- **elasticloadbalancing:DescribeLoadBalancerAttributes**
- **elasticloadbalancing:DescribeLoadBalancers**
- **elasticloadbalancing:DescribeTargetGroupAttributes**

- **elasticloadbalancing:DescribeTargetHealth**
- **elasticloadbalancing:ModifyLoadBalancerAttributes**
- **elasticloadbalancing:ModifyTargetGroup**
- **elasticloadbalancing:ModifyTargetGroupAttributes**
- **elasticloadbalancing:RegisterTargets**

Example 5.35. Required IAM permissions for installation

- **iam:AddRoleToInstanceProfile**
- **iam:CreateInstanceProfile**
- **iam:CreateRole**
- **iam:DeleteInstanceProfile**
- **iam:DeleteRole**
- **iam:DeleteRolePolicy**
- **iam:GetInstanceProfile**
- **iam:GetRole**
- **iam:GetRolePolicy**
- **iam:GetUser**
- **iam:ListInstanceProfilesForRole**
- **iam:ListRoles**
- **iam:ListUsers**
- **iam:PassRole**
- **iam:PutRolePolicy**
- **iam:RemoveRoleFromInstanceProfile**
- **iam:SimulatePrincipalPolicy**
- **iam:TagRole**

NOTE

If you have not created an elastic load balancer (ELB) in your AWS account, the IAM user also requires the **iam:CreateServiceLinkedRole** permission.

Example 5.36. Required Route 53 permissions for installation

- **route53:ChangeResourceRecordSets**
- **route53:ChangeTagsForResource**
- **route53:CreateHostedZone**
- **route53:DeleteHostedZone**
- **route53:GetChange**
- **route53:GetHostedZone**
- **route53:ListHostedZones**
- **route53:ListHostedZonesByName**
- **route53:ListResourceRecordSets**
- **route53:ListTagsForResource**
- **route53:UpdateHostedZoneComment**

Example 5.37. Required S3 permissions for installation

- **s3:CreateBucket**
- **s3:DeleteBucket**
- **s3:GetAccelerateConfiguration**
- **s3:GetBucketAcl**
- **s3:GetBucketCors**
- **s3:GetBucketLocation**
- **s3:GetBucketLogging**
- **s3:GetBucketPolicy**
- **s3:GetBucketObjectLockConfiguration**
- **s3:GetBucketReplication**
- **s3:GetBucketRequestPayment**
- **s3:GetBucketTagging**
- **s3:GetBucketVersioning**
- **s3:GetBucketWebsite**
- **s3:GetEncryptionConfiguration**
- **s3:GetLifecycleConfiguration**
- **s3:GetReplicationConfiguration**

- **s3:ListBucket**
- **s3:PutBucketAcl**
- **s3:PutBucketTagging**
- **s3:PutEncryptionConfiguration**

Example 5.38. S3 permissions that cluster Operators require

- **s3:DeleteObject**
- **s3:GetObject**
- **s3:GetObjectAcl**
- **s3:GetObjectTagging**
- **s3:GetObjectVersion**
- **s3:PutObject**
- **s3:PutObjectAcl**
- **s3:PutObjectTagging**

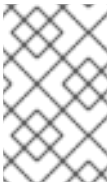
Example 5.39. Required permissions to delete base cluster resources

- **autoscaling:DescribeAutoScalingGroups**
- **ec2:DeletePlacementGroup**
- **ec2:DeleteNetworkInterface**
- **ec2:DeleteVolume**
- **elasticloadbalancing:DeleteTargetGroup**
- **elasticloadbalancing:DescribeTargetGroups**
- **iam:DeleteAccessKey**
- **iam:DeleteUser**
- **iam:ListAttachedRolePolicies**
- **iam:ListInstanceProfiles**
- **iam:ListRolePolicies**
- **iam:ListUserPolicies**
- **s3:DeleteObject**
- **s3:ListBucketVersions**

- **tag:GetResources**

Example 5.40. Required permissions to delete network resources

- **ec2:DeleteDhcpOptions**
- **ec2:DeleteInternetGateway**
- **ec2:DeleteNatGateway**
- **ec2:DeleteRoute**
- **ec2:DeleteRouteTable**
- **ec2:DeleteSubnet**
- **ec2:DeleteVpc**
- **ec2:DeleteVpcEndpoints**
- **ec2:DetachInternetGateway**
- **ec2:DisassociateRouteTable**
- **ec2:ReleaseAddress**
- **ec2:ReplaceRouteTableAssociation**



NOTE

If you use an existing VPC, your account does not require these permissions to delete network resources. Instead, your account only requires the **tag:UntagResources** permission to delete network resources.

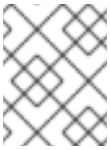
Example 5.41. Required permissions to delete a cluster with shared instance roles

- **iam:UntagRole**

Example 5.42. Additional IAM and S3 permissions that are required to create manifests

- **iam:DeleteAccessKey**
- **iam:DeleteUser**
- **iam:DeleteUserPolicy**
- **iam:GetUserPolicy**
- **iam:ListAccessKeys**
- **iam:PutUserPolicy**

- **iam:TagUser**
- **s3:PutBucketPublicAccessBlock**
- **s3:GetBucketPublicAccessBlock**
- **s3:PutLifecycleConfiguration**
- **s3:HeadBucket**
- **s3:ListBucketMultipartUploads**
- **s3:AbortMultipartUpload**



NOTE

If you are managing your cloud provider credentials with mint mode, the IAM user also requires the **iam:CreateAccessKey** and **iam:CreateUser** permissions.

Example 5.43. Optional permissions for instance and quota checks for installation

- **ec2:DescribeInstanceTypeOfferings**
- **servicequotas:ListAWSDefaultServiceQuotas**

5.13.5. Obtaining an AWS Marketplace image

If you are deploying an OpenShift Container Platform cluster using an AWS Marketplace image, you must first subscribe through AWS. Subscribing to the offer provides you with the AMI ID that the installation program uses to deploy worker nodes.

Prerequisites

- You have an AWS account to purchase the offer. This account does not have to be the same account that is used to install the cluster.

Procedure

1. Complete the OpenShift Container Platform subscription from the AWS Marketplace.
2. Record the AMI ID for your specific region. If you use the CloudFormation template to deploy your worker nodes, you must update the **worker0.type.properties.ImageID** parameter with this value.

5.13.6. Obtaining the installation program

Before you install OpenShift Container Platform, download the installation file on a local computer.

Prerequisites

- You have a computer that runs Linux or macOS, with 500 MB of local disk space.

Procedure

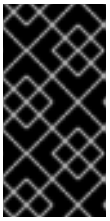
1. Access the Infrastructure Provider page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.

2. Select your infrastructure provider.

3. Navigate to the page for your installation type, download the installation program that corresponds with your host operating system and architecture, and place the file in the directory where you will store the installation configuration files.

IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.



IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

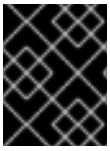
5. Download your installation pull secret from the Red Hat OpenShift Cluster Manager . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

5.13.7. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the **~/.ssh/authorized_keys** list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The **./openshift-install gather** command also requires the SSH public key to be in place on the cluster nodes.



IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.

NOTE

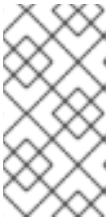
You must use a local key, not one that you configured with platform-specific approaches such as AWS key pairs.

Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N '' -f <path>/<file_name> 1
```

1 Specify the path and file name, such as **~/.ssh/id_ed25519**, of the new SSH key. If you have an existing key pair, ensure your public key is in the your **~/.ssh** directory.



NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS validated or Modules In Process cryptographic libraries on the **x86_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

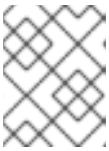
2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the **~/.ssh/id_ed25519.pub** public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the **./openshift-install gather** command.



NOTE

On some distributions, default SSH private key identities such as **~/.ssh/id_rsa** and **~/.ssh/id_dsa** are managed automatically.

a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

Example output

```
Agent pid 31874
```

NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

1 Specify the path and file name for your SSH private key, such as **~/.ssh/id_ed25519**

Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program. If you install a cluster on infrastructure that you provision, you must provide the key to the installation program.

5.13.8. Creating the installation files for AWS

To install OpenShift Container Platform on Amazon Web Services (AWS) using user-provisioned infrastructure, you must generate the files that the installation program needs to deploy your cluster and modify them so that the cluster creates only the machines that it will use. You generate and customize the **install-config.yaml** file, Kubernetes manifests, and Ignition config files. You also have the option to first set up a separate **var** partition during the preparation phases of installation.

5.13.8.1. Optional: Creating a separate /var partition

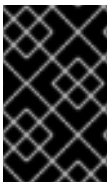
It is recommended that disk partitioning for OpenShift Container Platform be left to the installer. However, there are cases where you might want to create separate partitions in a part of the filesystem that you expect to grow.

OpenShift Container Platform supports the addition of a single partition to attach storage to either the **/var** partition or a subdirectory of **/var**. For example:

- **/var/lib/containers**: Holds container-related content that can grow as more images and containers are added to a system.
- **/var/lib/etcd**: Holds data that you might want to keep separate for purposes such as performance optimization of etcd storage.
- **/var**: Holds data that you might want to keep separate for purposes such as auditing.

Storing the contents of a **/var** directory separately makes it easier to grow storage for those areas as needed and reinstall OpenShift Container Platform at a later date and keep that data intact. With this method, you will not have to pull all your containers again, nor will you have to copy massive log files when you update systems.

Because **/var** must be in place before a fresh installation of Red Hat Enterprise Linux CoreOS (RHCOS), the following procedure sets up the separate **/var** partition by creating a machine config manifest that is inserted during the **openshift-install** preparation phases of an OpenShift Container Platform installation.



IMPORTANT

If you follow the steps to create a separate **/var** partition in this procedure, it is not necessary to create the Kubernetes manifest and Ignition config files again as described later in this section.

Procedure

1. Create a directory to hold the OpenShift Container Platform installation files:

```
$ mkdir $HOME/clusterconfig
```

2. Run **openshift-install** to create a set of files in the **manifest** and **openshift** subdirectories. Answer the system questions as you are prompted:

```
$ openshift-install create manifests --dir $HOME/clusterconfig
```

Example output

```
? SSH Public Key ...
INFO Credentials loaded from the "myprofile" profile in file "/home/myuser/.aws/credentials"
INFO Consuming Install Config from target directory
INFO Manifests created in: $HOME/clusterconfig/manifests and
$HOME/clusterconfig/openshift
```

3. Optional: Confirm that the installation program created manifests in the **clusterconfig/openshift** directory:

```
$ ls $HOME/clusterconfig/openshift/
```

Example output

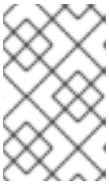
```
99_kubeadmin-password-secret.yaml
99_openshift-cluster-api_master-machines-0.yaml
99_openshift-cluster-api_master-machines-1.yaml
99_openshift-cluster-api_master-machines-2.yaml
...
```

4. Create a Butane config that configures the additional partition. For example, name the file **$HOME/clusterconfig/98-var-partition.bu**, change the disk device name to the name of the storage device on the **worker** systems, and set the storage size as appropriate. This example places the **/var** directory on a separate partition:

```
variant: openshift
version: 4.11.0
metadata:
  labels:
    machineconfiguration.openshift.io/role: worker
```

```
  name: 98-var-partition
storage:
  disks:
  - device: /dev/<device_name> 1
    partitions:
    - label: var
      start_mib: <partition_start_offset> 2
      size_mib: <partition_size> 3
  filesystems:
    - device: /dev/disk/by-partlabel/var
      path: /var
      format: xfs
      mount_options: [defaults, prjquota] 4
      with_mount_unit: true
```

1. The storage device name of the disk that you want to partition.
2. When adding a data partition to the boot disk, a minimum value of 25000 MiB (Mebibytes) is recommended. The root file system is automatically resized to fill all available space up to the specified offset. If no value is specified, or if the specified value is smaller than the recommended minimum, the resulting root file system will be too small, and future reinstalls of RHCOS might overwrite the beginning of the data partition.
3. The size of the data partition in mebibytes.
4. The **prjquota** mount option must be enabled for filesystems used for container storage.



NOTE

When creating a separate **/var** partition, you cannot use different instance types for worker nodes, if the different instance types do not have the same device name.

5. Create a manifest from the Butane config and save it to the **clusterconfig/openshift** directory. For example, run the following command:

```
$ butane $HOME/clusterconfig/98-var-partition.bu -o $HOME/clusterconfig/openshift/98-var-partition.yaml
```

6. Run **openshift-install** again to create Ignition configs from a set of files in the **manifest** and **openshift** subdirectories:

```
$ openshift-install create ignition-configs --dir $HOME/clusterconfig
$ ls $HOME/clusterconfig/
auth  bootstrap.ign  master.ign  metadata.json  worker.ign
```

Now you can use the Ignition config files as input to the installation procedures to install Red Hat Enterprise Linux CoreOS (RHCOS) systems.

5.13.8.2. Creating the installation configuration file

Generate and customize the installation configuration file that the installation program needs to deploy your cluster.

Prerequisites

- You obtained the OpenShift Container Platform installation program for user-provisioned infrastructure and the pull secret for your cluster.
- You checked that you are deploying your cluster to a region with an accompanying Red Hat Enterprise Linux CoreOS (RHCOS) AMI published by Red Hat. If you are deploying to a region that requires a custom AMI, such as an AWS GovCloud region, you must create the **install-config.yaml** file manually.

Procedure

1. Create the **install-config.yaml** file.
   a. Change to the directory that contains the installation program and run the following command:

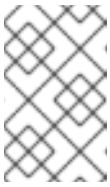
```
$ ./openshift-install create install-config --dir <installation_directory> 1
```

   1 For **<installation_directory>**, specify the directory name to store the files that the installation program creates.

IMPORTANT

Specify an empty directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

   b. At the prompts, provide the configuration details for your cloud:
      i. Optional: Select an SSH key to use to access your cluster machines.



NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

      ii. Select **aws** as the platform to target.
      iii. If you do not have an AWS profile stored on your computer, enter the AWS access key ID and secret access key for the user that you configured to run the installation program.

NOTE

The AWS access key ID and secret access key are stored in **~/.aws/credentials** in the home directory of the current user on the installation host. You are prompted for the credentials by the installation program if the credentials for the exported profile are not present in the file. Any credentials that you provide to the installation program are stored in the file.

iv. Select the AWS region to deploy the cluster to.

v. Select the base domain for the Route 53 service that you configured for your cluster.

vi. Enter a descriptive name for your cluster.

vii. Paste the pull secret from the Red Hat OpenShift Cluster Manager .

2. Optional: Back up the **install-config.yaml** file.

IMPORTANT

The **install-config.yaml** file is consumed during the installation process. If you want to reuse the file, you must back it up now.

Additional resources

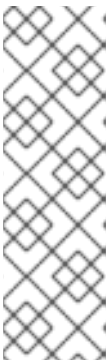
- See Configuration and credential file settings in the AWS documentation for more information about AWS profile and credential configuration.

5.13.8.3. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.



NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: ec2.<region>.amazonaws.com,elasticloadbalancing.
<region>.amazonaws.com,s3.<region>.amazonaws.com 3
additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
```

1. A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
2. A proxy URL to use for creating HTTPS connections outside the cluster.
3. A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use * to bypass the proxy for all destinations. If you have added the Amazon **EC2**,**Elastic Load Balancing**, and **S3** VPC endpoints to your VPC, you must add these endpoints to the **noProxy** field.
4. If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace that contains one or more additional CA certificates that are required for proxying HTTPS connections. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges these contents with the Red Hat Enterprise Linux CoreOS (RHCOS) trust bundle, and this config map is referenced in the **trustedCA** field of the **Proxy** object. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.

NOTE

The installation program does not support the proxy **readinessEndpoints** field.

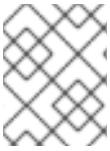
NOTE

If the installer times out, restart and then complete the deployment by using the **wait-for** command of the installer. For example:

```
$ ./openshift-install wait-for install-complete --log-level debug
```

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.



NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

5.13.8.4. Creating the Kubernetes manifest and Ignition config files

Because you must modify some cluster definition files and manually start the cluster machines, you must generate the Kubernetes manifest and Ignition config files that the cluster needs to configure the machines.

The installation configuration file transforms into the Kubernetes manifests. The manifests wrap into the Ignition configuration files, which are later used to configure the cluster machines.

IMPORTANT

- The Ignition config files that the OpenShift Container Platform installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

Prerequisites

- You obtained the OpenShift Container Platform installation program.
- You created the **install-config.yaml** installation configuration file.

Procedure

1. Change to the directory that contains the OpenShift Container Platform installation program and generate the Kubernetes manifests for the cluster:

```
$ ./openshift-install create manifests --dir <installation_directory> 1
```

1 For **<installation_directory>**, specify the installation directory that contains the **install-config.yaml** file you created.

2. Remove the Kubernetes manifest files that define the control plane machines:

```
$ rm -f <installation_directory>/openshift/99_openshift-cluster-api_master-machines-*.yaml
```

By removing these files, you prevent the cluster from automatically generating control plane machines.

3. Remove the Kubernetes manifest files that define the worker machines:

```
$ rm -f <installation_directory>/openshift/99_openshift-cluster-api_worker-machineset-*.yaml
```

Because you create and manage the worker machines yourself, you do not need to initialize these machines.

4. Check that the **mastersSchedulable** parameter in the **<installation_directory>/manifests/cluster-scheduler-02-config.yml** Kubernetes manifest file is set to **false**. This setting prevents pods from being scheduled on the control plane machines:

   a. Open the **<installation_directory>/manifests/cluster-scheduler-02-config.yml** file.

   b. Locate the **mastersSchedulable** parameter and ensure that it is set to **false**.

   c. Save and exit the file.

5. Optional: If you do not want the Ingress Operator to create DNS records on your behalf, remove the **privateZone** and **publicZone** sections from the **<installation_directory>/manifests/cluster-dns-02-config.yml** DNS configuration file:

```
apiVersion: config.openshift.io/v1
kind: DNS
metadata:
  creationTimestamp: null
  name: cluster
spec:
  baseDomain: example.openshift.com
  privateZone: 1
    id: mycluster-100419-private-zone
  publicZone: 2
    id: example.openshift.com
status: {}
```

1 2 Remove this section completely.

If you do so, you must add ingress DNS records manually in a later step.

6. To create the Ignition configuration files, run the following command from the directory that contains the installation program:

```
$ ./openshift-install create ignition-configs --dir <installation_directory> 1
```

1 For **<installation_directory>**, specify the same installation directory.

Ignition config files are created for the bootstrap, control plane, and compute nodes in the installation directory. The **kubeadmin-password** and **kubeconfig** files are created in the **./<installation_directory>/auth** directory:

```
.
├── auth
│   ├── kubeadmin-password
│   └── kubeconfig
├── bootstrap.ign
```

```
├── master.ign
├── metadata.json
└── worker.ign
```

5.13.9. Extracting the infrastructure name

The Ignition config files contain a unique cluster identifier that you can use to uniquely identify your cluster in Amazon Web Services (AWS). The infrastructure name is also used to locate the appropriate AWS resources during an OpenShift Container Platform installation. The provided CloudFormation templates contain references to this infrastructure name, so you must extract it.

Prerequisites

- You obtained the OpenShift Container Platform installation program and the pull secret for your cluster.
- You generated the Ignition config files for your cluster.
- You installed the **jq** package.

Procedure

- To extract and view the infrastructure name from the Ignition config file metadata, run the following command:

```
$ jq -r .infraID <installation_directory>/metadata.json 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

Example output

```
openshift-vw9j6 1
```

1 The output of this command is your cluster name and a random string.

5.13.10. Creating a VPC in AWS

You must create a Virtual Private Cloud (VPC) in Amazon Web Services (AWS) for your OpenShift Container Platform cluster to use. You can customize the VPC to meet your requirements, including VPN and route tables.

You can use the provided CloudFormation template and a custom parameter file to create a stack of AWS resources that represent the VPC.

NOTE

If you do not use the provided CloudFormation template to create your AWS infrastructure, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

Prerequisites

- You configured an AWS account.
- You added your AWS keys and region to your local AWS profile by running **aws configure**.
- You generated the Ignition config files for your cluster.

Procedure

1. Create a JSON file that contains the parameter values that the template requires:

```
[
  {
    "ParameterKey": "VpcCidr", 1
    "ParameterValue": "10.0.0.0/16" 2
  },
  {
    "ParameterKey": "AvailabilityZoneCount", 3
    "ParameterValue": "1" 4
  },
  {
    "ParameterKey": "SubnetBits", 5
    "ParameterValue": "12" 6
  }
]
```

1. The CIDR block for the VPC.
2. Specify a CIDR block in the format **x.x.x.x/16-24**.
3. The number of availability zones to deploy the VPC in.
4. Specify an integer between **1** and **3**.
5. The size of each subnet in each availability zone.
6. Specify an integer between **5** and **13**, where **5** is /**27** and **13** is /**19**.

2. Copy the template from the **CloudFormation template for the VPC**section of this topic and save it as a YAML file on your computer. This template describes the VPC that your cluster requires.

3. Launch the CloudFormation template to create a stack of AWS resources that represent the VPC:

IMPORTANT

You must enter the command on a single line.

```
$ aws cloudformation create-stack --stack-name <name> 1
    --template-body file://<template>.yaml 2
    --parameters file://<parameters>.json 3
```

1. **<name>** is the name for the CloudFormation stack, such as **cluster-vpc**. You need the name of this stack if you remove the cluster.
2. **<template>** is the relative path to and name of the CloudFormation template YAML file that you saved.
3. **<parameters>** is the relative path to and name of the CloudFormation parameters JSON file.

Example output

```
arn:aws:cloudformation:us-east-1:269333783861:stack/cluster-vpc/dbedae40-2fd3-11eb-820e-12a48460849f
```

4. Confirm that the template components exist:

```
$ aws cloudformation describe-stacks --stack-name <name>
```

After the **StackStatus** displays **CREATE_COMPLETE**, the output displays values for the following parameters. You must provide these parameter values to the other CloudFormation templates that you run to create your cluster:

VpcId	The ID of your VPC.
PublicSubnetIds	The IDs of the new public subnets.
PrivateSubnetIds	The IDs of the new private subnets.

5.13.10.1. CloudFormation template for the VPC

You can use the following CloudFormation template to deploy the VPC that you need for your OpenShift Container Platform cluster.

Example 5.44. CloudFormation template for the VPC

```
AWSTemplateFormatVersion: 2010-09-09
Description: Template for Best Practice VPC with 1-3 AZs

Parameters:
  VpcCidr:
    AllowedPattern: ^(([0-9]|[1-9][0-9]|1[0-9]{2}|2[0-4][0-9]|25[0-5])\.){3}([0-9]|[1-9][0-9]|1[0-9]{2}|2[0-4][0-9]|25[0-5])(\/(1[6-9]|2[0-4]))$
    ConstraintDescription: CIDR block parameter must be in the form x.x.x.x/16-24.
    Default: 10.0.0.0/16
    Description: CIDR block for VPC.
    Type: String
  AvailabilityZoneCount:
    ConstraintDescription: "The number of availability zones. (Min: 1, Max: 3)"
    MinValue: 1
    MaxValue: 3
```

```
    Default: 1
    Description: "How many AZs to create VPC subnets for. (Min: 1, Max: 3)"
    Type: Number
  SubnetBits:
    ConstraintDescription: CIDR block parameter must be in the form x.x.x.x/19-27.
    MinValue: 5
    MaxValue: 13
    Default: 12
    Description: "Size of each subnet to create within the availability zones. (Min: 5 = /27, Max: 13 =
/19)"
    Type: Number

Metadata:
  AWS::CloudFormation::Interface:
    ParameterGroups:
    - Label:
        default: "Network Configuration"
      Parameters:
      - VpcCidr
      - SubnetBits
    - Label:
        default: "Availability Zones"
      Parameters:
      - AvailabilityZoneCount
    ParameterLabels:
      AvailabilityZoneCount:
        default: "Availability Zone Count"
      VpcCidr:
        default: "VPC CIDR"
      SubnetBits:
        default: "Bits Per Subnet"

Conditions:
  DoAz3: !Equals [3, !Ref AvailabilityZoneCount]
  DoAz2: !Or [!Equals [2, !Ref AvailabilityZoneCount], Condition: DoAz3]

Resources:
  VPC:
    Type: "AWS::EC2::VPC"
    Properties:
      EnableDnsSupport: "true"
      EnableDnsHostnames: "true"
      CidrBlock: !Ref VpcCidr
  PublicSubnet:
    Type: "AWS::EC2::Subnet"
    Properties:
      VpcId: !Ref VPC
      CidrBlock: !Select [0, !Cidr [!Ref VpcCidr, 6, !Ref SubnetBits]]
      AvailabilityZone: !Select
      - 0
      - Fn::GetAZs: !Ref "AWS::Region"
  PublicSubnet2:
    Type: "AWS::EC2::Subnet"
    Condition: DoAz2
    Properties:
      VpcId: !Ref VPC
```

```
      CidrBlock: !Select [1, !Cidr [!Ref VpcCidr, 6, !Ref SubnetBits]]
      AvailabilityZone: !Select
      - 1
      - Fn::GetAZs: !Ref "AWS::Region"
  PublicSubnet3:
    Type: "AWS::EC2::Subnet"
    Condition: DoAz3
    Properties:
      VpcId: !Ref VPC
      CidrBlock: !Select [2, !Cidr [!Ref VpcCidr, 6, !Ref SubnetBits]]
      AvailabilityZone: !Select
      - 2
      - Fn::GetAZs: !Ref "AWS::Region"
  InternetGateway:
    Type: "AWS::EC2::InternetGateway"
  GatewayToInternet:
    Type: "AWS::EC2::VPCGatewayAttachment"
    Properties:
      VpcId: !Ref VPC
      InternetGatewayId: !Ref InternetGateway
  PublicRouteTable:
    Type: "AWS::EC2::RouteTable"
    Properties:
      VpcId: !Ref VPC
  PublicRoute:
    Type: "AWS::EC2::Route"
    DependsOn: GatewayToInternet
    Properties:
      RouteTableId: !Ref PublicRouteTable
      DestinationCidrBlock: 0.0.0.0/0
      GatewayId: !Ref InternetGateway
  PublicSubnetRouteTableAssociation:
    Type: "AWS::EC2::SubnetRouteTableAssociation"
    Properties:
      SubnetId: !Ref PublicSubnet
      RouteTableId: !Ref PublicRouteTable
  PublicSubnetRouteTableAssociation2:
    Type: "AWS::EC2::SubnetRouteTableAssociation"
    Condition: DoAz2
    Properties:
      SubnetId: !Ref PublicSubnet2
      RouteTableId: !Ref PublicRouteTable
  PublicSubnetRouteTableAssociation3:
    Condition: DoAz3
    Type: "AWS::EC2::SubnetRouteTableAssociation"
    Properties:
      SubnetId: !Ref PublicSubnet3
      RouteTableId: !Ref PublicRouteTable
  PrivateSubnet:
    Type: "AWS::EC2::Subnet"
    Properties:
      VpcId: !Ref VPC
      CidrBlock: !Select [3, !Cidr [!Ref VpcCidr, 6, !Ref SubnetBits]]
      AvailabilityZone: !Select
      - 0
      - Fn::GetAZs: !Ref "AWS::Region"
```

```
PrivateRouteTable:
  Type: "AWS::EC2::RouteTable"
  Properties:
    VpcId: !Ref VPC
PrivateSubnetRouteTableAssociation:
  Type: "AWS::EC2::SubnetRouteTableAssociation"
  Properties:
    SubnetId: !Ref PrivateSubnet
    RouteTableId: !Ref PrivateRouteTable
NAT:
  DependsOn:
  - GatewayToInternet
  Type: "AWS::EC2::NatGateway"
  Properties:
    AllocationId:
      "Fn::GetAtt":
      - EIP
      - AllocationId
    SubnetId: !Ref PublicSubnet
EIP:
  Type: "AWS::EC2::EIP"
  Properties:
    Domain: vpc
Route:
  Type: "AWS::EC2::Route"
  Properties:
    RouteTableId:
      Ref: PrivateRouteTable
    DestinationCidrBlock: 0.0.0.0/0
    NatGatewayId:
      Ref: NAT
PrivateSubnet2:
  Type: "AWS::EC2::Subnet"
  Condition: DoAz2
  Properties:
    VpcId: !Ref VPC
    CidrBlock: !Select [4, !Cidr [!Ref VpcCidr, 6, !Ref SubnetBits]]
    AvailabilityZone: !Select
    - 1
    - Fn::GetAZs: !Ref "AWS::Region"
PrivateRouteTable2:
  Type: "AWS::EC2::RouteTable"
  Condition: DoAz2
  Properties:
    VpcId: !Ref VPC
PrivateSubnetRouteTableAssociation2:
  Type: "AWS::EC2::SubnetRouteTableAssociation"
  Condition: DoAz2
  Properties:
    SubnetId: !Ref PrivateSubnet2
    RouteTableId: !Ref PrivateRouteTable2
NAT2:
  DependsOn:
  - GatewayToInternet
  Type: "AWS::EC2::NatGateway"
  Condition: DoAz2
```

```
  Properties:
    AllocationId:
      "Fn::GetAtt":
      - EIP2
      - AllocationId
    SubnetId: !Ref PublicSubnet2
EIP2:
  Type: "AWS::EC2::EIP"
  Condition: DoAz2
  Properties:
    Domain: vpc
Route2:
  Type: "AWS::EC2::Route"
  Condition: DoAz2
  Properties:
    RouteTableId:
      Ref: PrivateRouteTable2
    DestinationCidrBlock: 0.0.0.0/0
    NatGatewayId:
      Ref: NAT2
PrivateSubnet3:
  Type: "AWS::EC2::Subnet"
  Condition: DoAz3
  Properties:
    VpcId: !Ref VPC
    CidrBlock: !Select [5, !Cidr [!Ref VpcCidr, 6, !Ref SubnetBits]]
    AvailabilityZone: !Select
    - 2
    - Fn::GetAZs: !Ref "AWS::Region"
PrivateRouteTable3:
  Type: "AWS::EC2::RouteTable"
  Condition: DoAz3
  Properties:
    VpcId: !Ref VPC
PrivateSubnetRouteTableAssociation3:
  Type: "AWS::EC2::SubnetRouteTableAssociation"
  Condition: DoAz3
  Properties:
    SubnetId: !Ref PrivateSubnet3
    RouteTableId: !Ref PrivateRouteTable3
NAT3:
  DependsOn:
  - GatewayToInternet
  Type: "AWS::EC2::NatGateway"
  Condition: DoAz3
  Properties:
    AllocationId:
      "Fn::GetAtt":
      - EIP3
      - AllocationId
    SubnetId: !Ref PublicSubnet3
EIP3:
  Type: "AWS::EC2::EIP"
  Condition: DoAz3
  Properties:
    Domain: vpc
```

```
  Route3:
    Type: "AWS::EC2::Route"
    Condition: DoAz3
    Properties:
      RouteTableId:
        Ref: PrivateRouteTable3
      DestinationCidrBlock: 0.0.0.0/0
      NatGatewayId:
        Ref: NAT3
  S3Endpoint:
    Type: AWS::EC2::VPCEndpoint
    Properties:
      PolicyDocument:
        Version: 2012-10-17
        Statement:
        - Effect: Allow
          Principal: '*'
          Action:
          - '*'
          Resource:
          - '*'
      RouteTableIds:
      - !Ref PublicRouteTable
      - !Ref PrivateRouteTable
      - !If [DoAz2, !Ref PrivateRouteTable2, !Ref "AWS::NoValue"]
      - !If [DoAz3, !Ref PrivateRouteTable3, !Ref "AWS::NoValue"]
      ServiceName: !Join
      - ''
      - - com.amazonaws.
        - !Ref 'AWS::Region'
        - .s3
      VpcId: !Ref VPC

Outputs:
  VpcId:
    Description: ID of the new VPC.
    Value: !Ref VPC
  PublicSubnetIds:
    Description: Subnet IDs of the public subnets.
    Value:
      !Join [
        ",",
        [!Ref PublicSubnet, !If [DoAz2, !Ref PublicSubnet2, !Ref "AWS::NoValue"], !If [DoAz3, !Ref
PublicSubnet3, !Ref "AWS::NoValue"]]
      ]
  PrivateSubnetIds:
    Description: Subnet IDs of the private subnets.
    Value:
      !Join [
        ",",
        [!Ref PrivateSubnet, !If [DoAz2, !Ref PrivateSubnet2, !Ref "AWS::NoValue"], !If [DoAz3, !Ref
PrivateSubnet3, !Ref "AWS::NoValue"]]
      ]
```

Additional resources

Additional resources

- You can view details about the CloudFormation stacks that you create by navigating to the AWS CloudFormation console.

5.13.11. Creating networking and load balancing components in AWS

You must configure networking and classic or network load balancing in Amazon Web Services (AWS) that your OpenShift Container Platform cluster can use.

You can use the provided CloudFormation template and a custom parameter file to create a stack of AWS resources. The stack represents the networking and load balancing components that your OpenShift Container Platform cluster requires. The template also creates a hosted zone and subnet tags.

You can run the template multiple times within a single Virtual Private Cloud (VPC).

NOTE

If you do not use the provided CloudFormation template to create your AWS infrastructure, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

Prerequisites

- You configured an AWS account.
- You added your AWS keys and region to your local AWS profile by running **aws configure**.
- You generated the Ignition config files for your cluster.
- You created and configured a VPC and associated subnets in AWS.

Procedure

1. Obtain the hosted zone ID for the Route 53 base domain that you specified in the **install-config.yaml** file for your cluster. You can obtain details about your hosted zone by running the following command:

```
$ aws route53 list-hosted-zones-by-name --dns-name <route53_domain> 1
```

1 For the **<route53_domain>**, specify the Route 53 base domain that you used when you generated the **install-config.yaml** file for the cluster.

Example output

```
mycluster.example.com. False 100
HOSTEDZONES 65F8F38E-2268-B835-E15C-AB55336FCBFA
/hostedzone/Z21IXYZABCZ2A4 mycluster.example.com. 10
```

In the example output, the hosted zone ID is **Z21IXYZABCZ2A4**.

2. Create a JSON file that contains the parameter values that the template requires:

-

```
[
  {
    "ParameterKey": "ClusterName", 1
    "ParameterValue": "mycluster" 2
  },
  {
    "ParameterKey": "InfrastructureName", 3
    "ParameterValue": "mycluster-<random_string>" 4
  },
  {
    "ParameterKey": "HostedZoneId", 5
    "ParameterValue": "<random_string>" 6
  },
  {
    "ParameterKey": "HostedZoneName", 7
    "ParameterValue": "example.com" 8
  },
  {
    "ParameterKey": "PublicSubnets", 9
    "ParameterValue": "subnet-<random_string>" 10
  },
  {
    "ParameterKey": "PrivateSubnets", 11
    "ParameterValue": "subnet-<random_string>" 12
  },
  {
    "ParameterKey": "VpcId", 13
    "ParameterValue": "vpc-<random_string>" 14
  }
]
```

1. A short, representative cluster name to use for hostnames, etc.
2. Specify the cluster name that you used when you generated the **install-config.yaml** file for the cluster.
3. The name for your cluster infrastructure that is encoded in your Ignition config files for the cluster.
4. Specify the infrastructure name that you extracted from the Ignition config file metadata, which has the format **<cluster-name>-<random-string>**.
5. The Route 53 public zone ID to register the targets with.
6. Specify the Route 53 public zone ID, which as a format similar to **Z21IXYZABCZ2A4**. You can obtain this value from the AWS console.
7. The Route 53 zone to register the targets with.
8. Specify the Route 53 base domain that you used when you generated the **install-config.yaml** file for the cluster. Do not include the trailing period (.) that is displayed in the AWS console.
9. The public subnets that you created for your VPC.

10 Specify the **PublicSubnetIds** value from the output of the CloudFormation template for the VPC.

11 The private subnets that you created for your VPC.

12 Specify the **PrivateSubnetIds** value from the output of the CloudFormation template for the VPC.

13 The VPC that you created for the cluster.

14 Specify the **VpcId** value from the output of the CloudFormation template for the VPC.

3. Copy the template from the **CloudFormation template for the network and load balancers** section of this topic and save it as a YAML file on your computer. This template describes the networking and load balancing objects that your cluster requires.

IMPORTANT

If you are deploying your cluster to an AWS government or secret region, you must update the **InternalApiServerRecord** in the CloudFormation template to use **CNAME** records. Records of type **ALIAS** are not supported for AWS government regions.

4. Launch the CloudFormation template to create a stack of AWS resources that provide the networking and load balancing components:

IMPORTANT

You must enter the command on a single line.

```
$ aws cloudformation create-stack --stack-name <name> 1
    --template-body file://<template>.yaml 2
    --parameters file://<parameters>.json 3
    --capabilities CAPABILITY_NAMED_IAM 4
```

1 **<name>** is the name for the CloudFormation stack, such as **cluster-dns**. You need the name of this stack if you remove the cluster.

2 **<template>** is the relative path to and name of the CloudFormation template YAML file that you saved.

3 **<parameters>** is the relative path to and name of the CloudFormation parameters JSON file.

4 You must explicitly declare the **CAPABILITY_NAMED_IAM** capability because the provided template creates some **AWS::IAM::Role** resources.

Example output

```
arn:aws:cloudformation:us-east-1:269333783861:stack/cluster-dns/cd3e5de0-2fd4-11eb-5cf0-12be5c33a183
```

5. Confirm that the template components exist:

```
$ aws cloudformation describe-stacks --stack-name <name>
```

After the **StackStatus** displays **CREATE_COMPLETE**, the output displays values for the following parameters. You must provide these parameter values to the other CloudFormation templates that you run to create your cluster:

PrivateHostedZoneId	Hosted zone ID for the private DNS.
ExternalApiLoadBalancerName	Full name of the external API load balancer.
InternalApiLoadBalancerName	Full name of the internal API load balancer.
ApiServerDnsName	Full hostname of the API server.
RegisterNlbIpTargetsLambda	Lambda ARN useful to help register/deregister IP targets for these load balancers.
ExternalApiTargetGroupArn	ARN of external API target group.
InternalApiTargetGroupArn	ARN of internal API target group.
InternalServiceTargetGroupArn	ARN of internal service target group.

5.13.11.1. CloudFormation template for the network and load balancers

You can use the following CloudFormation template to deploy the networking objects and load balancers that you need for your OpenShift Container Platform cluster.

Example 5.45. CloudFormation template for the network and load balancers

```
AWSTemplateFormatVersion: 2010-09-09
Description: Template for OpenShift Cluster Network Elements (Route53 & LBs)
```

```
Parameters:
  ClusterName:
    AllowedPattern: ^([a-zA-Z][a-zA-Z0-9\-]{0,26})$
    MaxLength: 27
    MinLength: 1
    ConstraintDescription: Cluster name must be alphanumeric, start with a letter, and have a
maximum of 27 characters.
    Description: A short, representative cluster name to use for host names and other identifying
names.
    Type: String
  InfrastructureName:
    AllowedPattern: ^([a-zA-Z][a-zA-Z0-9\-]{0,26})$
    MaxLength: 27
    MinLength: 1
    ConstraintDescription: Infrastructure name must be alphanumeric, start with a letter, and have a
maximum of 27 characters.
    Description: A short, unique cluster ID used to tag cloud resources and identify items owned or
used by the cluster.
    Type: String
  HostedZoneId:
    Description: The Route53 public zone ID to register the targets with, such as
Z21IXYZABCZ2A4.
    Type: String
  HostedZoneName:
    Description: The Route53 zone to register the targets with, such as example.com. Omit the
trailing period.
    Type: String
    Default: "example.com"
  PublicSubnets:
    Description: The internet-facing subnets.
    Type: List<AWS::EC2::Subnet::Id>
  PrivateSubnets:
    Description: The internal subnets.
    Type: List<AWS::EC2::Subnet::Id>
  VpcId:
    Description: The VPC-scoped resources will belong to this VPC.
    Type: AWS::EC2::VPC::Id

Metadata:
  AWS::CloudFormation::Interface:
    ParameterGroups:
    - Label:
        default: "Cluster Information"
      Parameters:
      - ClusterName
      - InfrastructureName
    - Label:
        default: "Network Configuration"
      Parameters:
      - VpcId
      - PublicSubnets
      - PrivateSubnets
    - Label:
        default: "DNS"
      Parameters:
      - HostedZoneName
```

```
      - HostedZoneId
    ParameterLabels:
      ClusterName:
        default: "Cluster Name"
      InfrastructureName:
        default: "Infrastructure Name"
      VpcId:
        default: "VPC ID"
      PublicSubnets:
        default: "Public Subnets"
      PrivateSubnets:
        default: "Private Subnets"
      HostedZoneName:
        default: "Public Hosted Zone Name"
      HostedZoneId:
        default: "Public Hosted Zone ID"

Resources:
  ExtApiElb:
    Type: AWS::ElasticLoadBalancingV2::LoadBalancer
    Properties:
      Name: !Join ["-", [!Ref InfrastructureName, "ext"]]
      IpAddressType: ipv4
      Subnets: !Ref PublicSubnets
      Type: network

  IntApiElb:
    Type: AWS::ElasticLoadBalancingV2::LoadBalancer
    Properties:
      Name: !Join ["-", [!Ref InfrastructureName, "int"]]
      Scheme: internal
      IpAddressType: ipv4
      Subnets: !Ref PrivateSubnets
      Type: network

  IntDns:
    Type: "AWS::Route53::HostedZone"
    Properties:
      HostedZoneConfig:
        Comment: "Managed by CloudFormation"
      Name: !Join [".", [!Ref ClusterName, !Ref HostedZoneName]]
      HostedZoneTags:
      - Key: Name
        Value: !Join ["-", [!Ref InfrastructureName, "int"]]
      - Key: !Join ["", ["kubernetes.io/cluster/", !Ref InfrastructureName]]
        Value: "owned"
      VPCs:
      - VPCId: !Ref VpcId
        VPCRegion: !Ref "AWS::Region"

  ExternalApiServerRecord:
    Type: AWS::Route53::RecordSetGroup
    Properties:
      Comment: Alias record for the API server
      HostedZoneId: !Ref HostedZoneId
      RecordSets:
```

```
      - Name:
          !Join [
            ".",
            ["api", !Ref ClusterName, !Join ["", [!Ref HostedZoneName, "."]]],
          ]
        Type: A
        AliasTarget:
          HostedZoneId: !GetAtt ExtApiElb.CanonicalHostedZoneID
          DNSName: !GetAtt ExtApiElb.DNSName

  InternalApiServerRecord:
    Type: AWS::Route53::RecordSetGroup
    Properties:
      Comment: Alias record for the API server
      HostedZoneId: !Ref IntDns
      RecordSets:
      - Name:
          !Join [
            ".",
            ["api", !Ref ClusterName, !Join ["", [!Ref HostedZoneName, "."]]],
          ]
        Type: A
        AliasTarget:
          HostedZoneId: !GetAtt IntApiElb.CanonicalHostedZoneID
          DNSName: !GetAtt IntApiElb.DNSName
      - Name:
          !Join [
            ".",
            ["api-int", !Ref ClusterName, !Join ["", [!Ref HostedZoneName, "."]]],
          ]
        Type: A
        AliasTarget:
          HostedZoneId: !GetAtt IntApiElb.CanonicalHostedZoneID
          DNSName: !GetAtt IntApiElb.DNSName

  ExternalApiListener:
    Type: AWS::ElasticLoadBalancingV2::Listener
    Properties:
      DefaultActions:
      - Type: forward
        TargetGroupArn:
          Ref: ExternalApiTargetGroup
      LoadBalancerArn:
        Ref: ExtApiElb
      Port: 6443
      Protocol: TCP

  ExternalApiTargetGroup:
    Type: AWS::ElasticLoadBalancingV2::TargetGroup
    Properties:
      HealthCheckIntervalSeconds: 10
      HealthCheckPath: "/readyz"
      HealthCheckPort: 6443
      HealthCheckProtocol: HTTPS
      HealthyThresholdCount: 2
      UnhealthyThresholdCount: 2
```

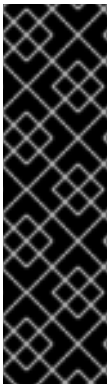
```
    Port: 6443
    Protocol: TCP
    TargetType: ip
    VpcId:
      Ref: VpcId
    TargetGroupAttributes:
    - Key: deregistration_delay.timeout_seconds
      Value: 60

  InternalApiListener:
    Type: AWS::ElasticLoadBalancingV2::Listener
    Properties:
      DefaultActions:
      - Type: forward
        TargetGroupArn:
          Ref: InternalApiTargetGroup
      LoadBalancerArn:
        Ref: IntApiElb
      Port: 6443
      Protocol: TCP

  InternalApiTargetGroup:
    Type: AWS::ElasticLoadBalancingV2::TargetGroup
    Properties:
      HealthCheckIntervalSeconds: 10
      HealthCheckPath: "/readyz"
      HealthCheckPort: 6443
      HealthCheckProtocol: HTTPS
      HealthyThresholdCount: 2
      UnhealthyThresholdCount: 2
      Port: 6443
      Protocol: TCP
      TargetType: ip
      VpcId:
        Ref: VpcId
      TargetGroupAttributes:
      - Key: deregistration_delay.timeout_seconds
        Value: 60

  InternalServiceInternalListener:
    Type: AWS::ElasticLoadBalancingV2::Listener
    Properties:
      DefaultActions:
      - Type: forward
        TargetGroupArn:
          Ref: InternalServiceTargetGroup
      LoadBalancerArn:
        Ref: IntApiElb
      Port: 22623
      Protocol: TCP

  InternalServiceTargetGroup:
    Type: AWS::ElasticLoadBalancingV2::TargetGroup
    Properties:
      HealthCheckIntervalSeconds: 10
      HealthCheckPath: "/healthz"
```

```
    HealthCheckPort: 22623
    HealthCheckProtocol: HTTPS
    HealthyThresholdCount: 2
    UnhealthyThresholdCount: 2
    Port: 22623
    Protocol: TCP
    TargetType: ip
    VpcId:
      Ref: VpcId
    TargetGroupAttributes:
    - Key: deregistration_delay.timeout_seconds
      Value: 60

  RegisterTargetLambdaIamRole:
    Type: AWS::IAM::Role
    Properties:
      RoleName: !Join ["-", [!Ref InfrastructureName, "nlb", "lambda", "role"]]
      AssumeRolePolicyDocument:
        Version: "2012-10-17"
        Statement:
        - Effect: "Allow"
          Principal:
            Service:
            - "lambda.amazonaws.com"
          Action:
          - "sts:AssumeRole"
      Path: "/"
      Policies:
      - PolicyName: !Join ["-", [!Ref InfrastructureName, "master", "policy"]]
        PolicyDocument:
          Version: "2012-10-17"
          Statement:
          - Effect: "Allow"
            Action:
              [
                "elasticloadbalancing:RegisterTargets",
                "elasticloadbalancing:DeregisterTargets",
              ]
            Resource: !Ref InternalApiTargetGroup
          - Effect: "Allow"
            Action:
              [
                "elasticloadbalancing:RegisterTargets",
                "elasticloadbalancing:DeregisterTargets",
              ]
            Resource: !Ref InternalServiceTargetGroup
          - Effect: "Allow"
            Action:
              [
                "elasticloadbalancing:RegisterTargets",
                "elasticloadbalancing:DeregisterTargets",
              ]
            Resource: !Ref ExternalApiTargetGroup

  RegisterNlbIpTargets:
    Type: "AWS::Lambda::Function"
```

```
    Properties:
      Handler: "index.handler"
      Role:
        Fn::GetAtt:
        - "RegisterTargetLambdaIamRole"
        - "Arn"
      Code:
        ZipFile: |
          import json
          import boto3
          import cfnresponse
          def handler(event, context):
            elb = boto3.client('elbv2')
            if event['RequestType'] == 'Delete':
              elb.deregister_targets(TargetGroupArn=event['ResourceProperties']
['TargetArn'],Targets=[{'Id': event['ResourceProperties']['TargetIp']}])
            elif event['RequestType'] == 'Create':
              elb.register_targets(TargetGroupArn=event['ResourceProperties']['TargetArn'],Targets=
[{'Id': event['ResourceProperties']['TargetIp']}])
            responseData = {}
            cfnresponse.send(event, context, cfnresponse.SUCCESS, responseData,
event['ResourceProperties']['TargetArn']+event['ResourceProperties']['TargetIp'])
      Runtime: "python3.7"
      Timeout: 120

  RegisterSubnetTagsLambdaIamRole:
    Type: AWS::IAM::Role
    Properties:
      RoleName: !Join ["-", [!Ref InfrastructureName, "subnet-tags-lambda-role"]]
      AssumeRolePolicyDocument:
        Version: "2012-10-17"
        Statement:
        - Effect: "Allow"
          Principal:
            Service:
            - "lambda.amazonaws.com"
          Action:
          - "sts:AssumeRole"
      Path: "/"
      Policies:
      - PolicyName: !Join ["-", [!Ref InfrastructureName, "subnet-tagging-policy"]]
        PolicyDocument:
          Version: "2012-10-17"
          Statement:
          - Effect: "Allow"
            Action:
              [
                "ec2:DeleteTags",
                "ec2:CreateTags"
              ]
            Resource: "arn:aws:ec2:*:*:subnet/*"
          - Effect: "Allow"
            Action:
              [
                "ec2:DescribeSubnets",
                "ec2:DescribeTags"
```

```
            ]
           Resource: "*"

  RegisterSubnetTags:
    Type: "AWS::Lambda::Function"
    Properties:
      Handler: "index.handler"
      Role:
        Fn::GetAtt:
        - "RegisterSubnetTagsLambdaIamRole"
        - "Arn"
      Code:
        ZipFile: |
          import json
          import boto3
          import cfnresponse
          def handler(event, context):
            ec2_client = boto3.client('ec2')
            if event['RequestType'] == 'Delete':
              for subnet_id in event['ResourceProperties']['Subnets']:
                ec2_client.delete_tags(Resources=[subnet_id], Tags=[{'Key': 'kubernetes.io/cluster/' +
event['ResourceProperties']['InfrastructureName']}]);
            elif event['RequestType'] == 'Create':
              for subnet_id in event['ResourceProperties']['Subnets']:
                ec2_client.create_tags(Resources=[subnet_id], Tags=[{'Key': 'kubernetes.io/cluster/' +
event['ResourceProperties']['InfrastructureName'], 'Value': 'shared'}]);
            responseData = {}
            cfnresponse.send(event, context, cfnresponse.SUCCESS, responseData,
event['ResourceProperties']['InfrastructureName']+event['ResourceProperties']['Subnets'][0])
      Runtime: "python3.7"
      Timeout: 120

  RegisterPublicSubnetTags:
    Type: Custom::SubnetRegister
    Properties:
      ServiceToken: !GetAtt RegisterSubnetTags.Arn
      InfrastructureName: !Ref InfrastructureName
      Subnets: !Ref PublicSubnets

  RegisterPrivateSubnetTags:
    Type: Custom::SubnetRegister
    Properties:
      ServiceToken: !GetAtt RegisterSubnetTags.Arn
      InfrastructureName: !Ref InfrastructureName
      Subnets: !Ref PrivateSubnets

Outputs:
  PrivateHostedZoneId:
    Description: Hosted zone ID for the private DNS, which is required for private records.
    Value: !Ref IntDns
  ExternalApiLoadBalancerName:
    Description: Full name of the external API load balancer.
    Value: !GetAtt ExtApiElb.LoadBalancerFullName
  InternalApiLoadBalancerName:
    Description: Full name of the internal API load balancer.
    Value: !GetAtt IntApiElb.LoadBalancerFullName
```

```
  ApiServerDnsName:
    Description: Full hostname of the API server, which is required for the Ignition config files.
    Value: !Join [".", ["api-int", !Ref ClusterName, !Ref HostedZoneName]]
  RegisterNlbIpTargetsLambda:
    Description: Lambda ARN useful to help register or deregister IP targets for these load
balancers.
    Value: !GetAtt RegisterNlbIpTargets.Arn
  ExternalApiTargetGroupArn:
    Description: ARN of the external API target group.
    Value: !Ref ExternalApiTargetGroup
  InternalApiTargetGroupArn:
    Description: ARN of the internal API target group.
    Value: !Ref InternalApiTargetGroup
  InternalServiceTargetGroupArn:
    Description: ARN of the internal service target group.
    Value: !Ref InternalServiceTargetGroup
```



IMPORTANT

If you are deploying your cluster to an AWS government or secret region, you must update the **InternalApiServerRecord** to use **CNAME** records. Records of type **ALIAS** are not supported for AWS government regions. For example:

```
Type: CNAME
TTL: 10
ResourceRecords:
- !GetAtt IntApiElb.DNSName
```

Additional resources

- You can view details about the CloudFormation stacks that you create by navigating to the AWS CloudFormation console.
- You can view details about your hosted zones by navigating to the AWS Route 53 console .
- See Listing public hosted zones in the AWS documentation for more information about listing public hosted zones.

5.13.12. Creating security group and roles in AWS

You must create security groups and roles in Amazon Web Services (AWS) for your OpenShift Container Platform cluster to use.

You can use the provided CloudFormation template and a custom parameter file to create a stack of AWS resources. The stack represents the security groups and roles that your OpenShift Container Platform cluster requires.

NOTE

If you do not use the provided CloudFormation template to create your AWS infrastructure, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

Prerequisites

- You configured an AWS account.
- You added your AWS keys and region to your local AWS profile by running **aws configure**.
- You generated the Ignition config files for your cluster.
- You created and configured a VPC and associated subnets in AWS.

Procedure

1. Create a JSON file that contains the parameter values that the template requires:

```
[
  {
    "ParameterKey": "InfrastructureName", 1
    "ParameterValue": "mycluster-<random_string>" 2
  },
  {
    "ParameterKey": "VpcCidr", 3
    "ParameterValue": "10.0.0.0/16" 4
  },
  {
    "ParameterKey": "PrivateSubnets", 5
    "ParameterValue": "subnet-<random_string>" 6
  },
  {
    "ParameterKey": "VpcId", 7
    "ParameterValue": "vpc-<random_string>" 8
  }
]
```

1. The name for your cluster infrastructure that is encoded in your Ignition config files for the cluster.
2. Specify the infrastructure name that you extracted from the Ignition config file metadata, which has the format **<cluster-name>-<random-string>**.
3. The CIDR block for the VPC.
4. Specify the CIDR block parameter that you used for the VPC that you defined in the form **x.x.x.x/16-24**.
5. The private subnets that you created for your VPC.
6. Specify the **PrivateSubnetIds** value from the output of the CloudFormation template for the VPC.
7. The VPC that you created for the cluster.
8. Specify the **VpcId** value from the output of the CloudFormation template for the VPC.

2. Copy the template from the **CloudFormation template for security objects** section of this topic and save it as a YAML file on your computer. This template describes the security groups and roles that your cluster requires.

3. Launch the CloudFormation template to create a stack of AWS resources that represent the security groups and roles:

IMPORTANT

You must enter the command on a single line.

```
$ aws cloudformation create-stack --stack-name <name> 1
    --template-body file://<template>.yaml 2
    --parameters file://<parameters>.json 3
    --capabilities CAPABILITY_NAMED_IAM 4
```

1 **<name>** is the name for the CloudFormation stack, such as **cluster-sec**. You need the name of this stack if you remove the cluster.

2 **<template>** is the relative path to and name of the CloudFormation template YAML file that you saved.

3 **<parameters>** is the relative path to and name of the CloudFormation parameters JSON file.

4 You must explicitly declare the **CAPABILITY_NAMED_IAM** capability because the provided template creates some **AWS::IAM::Role** and **AWS::IAM::InstanceProfile** resources.

Example output

```
arn:aws:cloudformation:us-east-1:269333783861:stack/cluster-sec/03bd4210-2ed7-11eb-6d7a-13fc0b61e9db
```

4. Confirm that the template components exist:

```
$ aws cloudformation describe-stacks --stack-name <name>
```

After the **StackStatus** displays **CREATE_COMPLETE**, the output displays values for the following parameters. You must provide these parameter values to the other CloudFormation templates that you run to create your cluster:

MasterSecurityGroupId	Master Security Group ID
WorkerSecurityGroupId	Worker Security Group ID

MasterInstanceProfile	Master IAM Instance Profile
WorkerInstanceProfile	Worker IAM Instance Profile

5.13.12.1. CloudFormation template for security objects

You can use the following CloudFormation template to deploy the security objects that you need for your OpenShift Container Platform cluster.

Example 5.46. CloudFormation template for security objects

```
AWSTemplateFormatVersion: 2010-09-09
Description: Template for OpenShift Cluster Security Elements (Security Groups & IAM)

Parameters:
  InfrastructureName:
    AllowedPattern: ^([a-zA-Z][a-zA-Z0-9\-]{0,26})$
    MaxLength: 27
    MinLength: 1
    ConstraintDescription: Infrastructure name must be alphanumeric, start with a letter, and have a
maximum of 27 characters.
    Description: A short, unique cluster ID used to tag cloud resources and identify items owned or
used by the cluster.
    Type: String
  VpcCidr:
    AllowedPattern: ^(([0-9]|[1-9][0-9]|1[0-9]{2}|2[0-4][0-9]|25[0-5])\.){3}([0-9]|[1-9][0-9]|1[0-9]{2}|2[0-
4][0-9]|25[0-5])(\/(1[6-9]|2[0-4]))$
    ConstraintDescription: CIDR block parameter must be in the form x.x.x.x/16-24.
    Default: 10.0.0.0/16
    Description: CIDR block for VPC.
    Type: String
  VpcId:
    Description: The VPC-scoped resources will belong to this VPC.
    Type: AWS::EC2::VPC::Id
  PrivateSubnets:
    Description: The internal subnets.
    Type: List<AWS::EC2::Subnet::Id>

Metadata:
  AWS::CloudFormation::Interface:
    ParameterGroups:
    - Label:
        default: "Cluster Information"
      Parameters:
      - InfrastructureName
    - Label:
        default: "Network Configuration"
      Parameters:
```

```
      - VpcId
      - VpcCidr
      - PrivateSubnets
    ParameterLabels:
      InfrastructureName:
        default: "Infrastructure Name"
      VpcId:
        default: "VPC ID"
      VpcCidr:
        default: "VPC CIDR"
      PrivateSubnets:
        default: "Private Subnets"

Resources:
  MasterSecurityGroup:
    Type: AWS::EC2::SecurityGroup
    Properties:
      GroupDescription: Cluster Master Security Group
      SecurityGroupIngress:
      - IpProtocol: icmp
        FromPort: 0
        ToPort: 0
        CidrIp: !Ref VpcCidr
      - IpProtocol: tcp
        FromPort: 22
        ToPort: 22
        CidrIp: !Ref VpcCidr
      - IpProtocol: tcp
        ToPort: 6443
        FromPort: 6443
        CidrIp: !Ref VpcCidr
      - IpProtocol: tcp
        FromPort: 22623
        ToPort: 22623
        CidrIp: !Ref VpcCidr
      VpcId: !Ref VpcId

  WorkerSecurityGroup:
    Type: AWS::EC2::SecurityGroup
    Properties:
      GroupDescription: Cluster Worker Security Group
      SecurityGroupIngress:
      - IpProtocol: icmp
        FromPort: 0
        ToPort: 0
        CidrIp: !Ref VpcCidr
      - IpProtocol: tcp
        FromPort: 22
        ToPort: 22
        CidrIp: !Ref VpcCidr
      VpcId: !Ref VpcId

  MasterIngressEtcd:
    Type: AWS::EC2::SecurityGroupIngress
    Properties:
      GroupId: !GetAtt MasterSecurityGroup.GroupId
```

```
      SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId
      Description: etcd
      FromPort: 2379
      ToPort: 2380
      IpProtocol: tcp

  MasterIngressVxlan:
    Type: AWS::EC2::SecurityGroupIngress
    Properties:
      GroupId: !GetAtt MasterSecurityGroup.GroupId
      SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId
      Description: Vxlan packets
      FromPort: 4789
      ToPort: 4789
      IpProtocol: udp

  MasterIngressWorkerVxlan:
    Type: AWS::EC2::SecurityGroupIngress
    Properties:
      GroupId: !GetAtt MasterSecurityGroup.GroupId
      SourceSecurityGroupId: !GetAtt WorkerSecurityGroup.GroupId
      Description: Vxlan packets
      FromPort: 4789
      ToPort: 4789
      IpProtocol: udp

  MasterIngressGeneve:
    Type: AWS::EC2::SecurityGroupIngress
    Properties:
      GroupId: !GetAtt MasterSecurityGroup.GroupId
      SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId
      Description: Geneve packets
      FromPort: 6081
      ToPort: 6081
      IpProtocol: udp

  MasterIngressWorkerGeneve:
    Type: AWS::EC2::SecurityGroupIngress
    Properties:
      GroupId: !GetAtt MasterSecurityGroup.GroupId
      SourceSecurityGroupId: !GetAtt WorkerSecurityGroup.GroupId
      Description: Geneve packets
      FromPort: 6081
      ToPort: 6081
      IpProtocol: udp

  MasterIngressIpsecIke:
    Type: AWS::EC2::SecurityGroupIngress
    Properties:
      GroupId: !GetAtt MasterSecurityGroup.GroupId
      SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId
      Description: IPsec IKE packets
      FromPort: 500
      ToPort: 500
      IpProtocol: udp
```

```
MasterIngressIpsecNat:
  Type: AWS::EC2::SecurityGroupIngress
  Properties:
    GroupId: !GetAtt MasterSecurityGroup.GroupId
    SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId
    Description: IPsec NAT-T packets
    FromPort: 4500
    ToPort: 4500
    IpProtocol: udp

MasterIngressIpsecEsp:
  Type: AWS::EC2::SecurityGroupIngress
  Properties:
    GroupId: !GetAtt MasterSecurityGroup.GroupId
    SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId
    Description: IPsec ESP packets
    IpProtocol: 50

MasterIngressWorkerIpsecIke:
  Type: AWS::EC2::SecurityGroupIngress
  Properties:
    GroupId: !GetAtt MasterSecurityGroup.GroupId
    SourceSecurityGroupId: !GetAtt WorkerSecurityGroup.GroupId
    Description: IPsec IKE packets
    FromPort: 500
    ToPort: 500
    IpProtocol: udp

MasterIngressWorkerIpsecNat:
  Type: AWS::EC2::SecurityGroupIngress
  Properties:
    GroupId: !GetAtt MasterSecurityGroup.GroupId
    SourceSecurityGroupId: !GetAtt WorkerSecurityGroup.GroupId
    Description: IPsec NAT-T packets
    FromPort: 4500
    ToPort: 4500
    IpProtocol: udp

MasterIngressWorkerIpsecEsp:
  Type: AWS::EC2::SecurityGroupIngress
  Properties:
    GroupId: !GetAtt MasterSecurityGroup.GroupId
    SourceSecurityGroupId: !GetAtt WorkerSecurityGroup.GroupId
    Description: IPsec ESP packets
    IpProtocol: 50

MasterIngressInternal:
  Type: AWS::EC2::SecurityGroupIngress
  Properties:
    GroupId: !GetAtt MasterSecurityGroup.GroupId
    SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId
    Description: Internal cluster communication
    FromPort: 9000
    ToPort: 9999
    IpProtocol: tcp
```

```
MasterIngressWorkerInternal:
  Type: AWS::EC2::SecurityGroupIngress
  Properties:
    GroupId: !GetAtt MasterSecurityGroup.GroupId
    SourceSecurityGroupId: !GetAtt WorkerSecurityGroup.GroupId
    Description: Internal cluster communication
    FromPort: 9000
    ToPort: 9999
    IpProtocol: tcp

MasterIngressInternalUDP:
  Type: AWS::EC2::SecurityGroupIngress
  Properties:
    GroupId: !GetAtt MasterSecurityGroup.GroupId
    SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId
    Description: Internal cluster communication
    FromPort: 9000
    ToPort: 9999
    IpProtocol: udp

MasterIngressWorkerInternalUDP:
  Type: AWS::EC2::SecurityGroupIngress
  Properties:
    GroupId: !GetAtt MasterSecurityGroup.GroupId
    SourceSecurityGroupId: !GetAtt WorkerSecurityGroup.GroupId
    Description: Internal cluster communication
    FromPort: 9000
    ToPort: 9999
    IpProtocol: udp

MasterIngressKube:
  Type: AWS::EC2::SecurityGroupIngress
  Properties:
    GroupId: !GetAtt MasterSecurityGroup.GroupId
    SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId
    Description: Kubernetes kubelet, scheduler and controller manager
    FromPort: 10250
    ToPort: 10259
    IpProtocol: tcp

MasterIngressWorkerKube:
  Type: AWS::EC2::SecurityGroupIngress
  Properties:
    GroupId: !GetAtt MasterSecurityGroup.GroupId
    SourceSecurityGroupId: !GetAtt WorkerSecurityGroup.GroupId
    Description: Kubernetes kubelet, scheduler and controller manager
    FromPort: 10250
    ToPort: 10259
    IpProtocol: tcp

MasterIngressIngressServices:
  Type: AWS::EC2::SecurityGroupIngress
  Properties:
    GroupId: !GetAtt MasterSecurityGroup.GroupId
    SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId
    Description: Kubernetes ingress services
```

```
    FromPort: 30000
    ToPort: 32767
    IpProtocol: tcp

MasterIngressWorkerIngressServices:
  Type: AWS::EC2::SecurityGroupIngress
  Properties:
    GroupId: !GetAtt MasterSecurityGroup.GroupId
    SourceSecurityGroupId: !GetAtt WorkerSecurityGroup.GroupId
    Description: Kubernetes ingress services
    FromPort: 30000
    ToPort: 32767
    IpProtocol: tcp

MasterIngressIngressServicesUDP:
  Type: AWS::EC2::SecurityGroupIngress
  Properties:
    GroupId: !GetAtt MasterSecurityGroup.GroupId
    SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId
    Description: Kubernetes ingress services
    FromPort: 30000
    ToPort: 32767
    IpProtocol: udp

MasterIngressWorkerIngressServicesUDP:
  Type: AWS::EC2::SecurityGroupIngress
  Properties:
    GroupId: !GetAtt MasterSecurityGroup.GroupId
    SourceSecurityGroupId: !GetAtt WorkerSecurityGroup.GroupId
    Description: Kubernetes ingress services
    FromPort: 30000
    ToPort: 32767
    IpProtocol: udp

WorkerIngressVxlan:
  Type: AWS::EC2::SecurityGroupIngress
  Properties:
    GroupId: !GetAtt WorkerSecurityGroup.GroupId
    SourceSecurityGroupId: !GetAtt WorkerSecurityGroup.GroupId
    Description: Vxlan packets
    FromPort: 4789
    ToPort: 4789
    IpProtocol: udp

WorkerIngressMasterVxlan:
  Type: AWS::EC2::SecurityGroupIngress
  Properties:
    GroupId: !GetAtt WorkerSecurityGroup.GroupId
    SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId
    Description: Vxlan packets
    FromPort: 4789
    ToPort: 4789
    IpProtocol: udp

WorkerIngressGeneve:
  Type: AWS::EC2::SecurityGroupIngress
```

```
    Properties:
      GroupId: !GetAtt WorkerSecurityGroup.GroupId
      SourceSecurityGroupId: !GetAtt WorkerSecurityGroup.GroupId
      Description: Geneve packets
      FromPort: 6081
      ToPort: 6081
      IpProtocol: udp

  WorkerIngressMasterGeneve:
    Type: AWS::EC2::SecurityGroupIngress
    Properties:
      GroupId: !GetAtt WorkerSecurityGroup.GroupId
      SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId
      Description: Geneve packets
      FromPort: 6081
      ToPort: 6081
      IpProtocol: udp

  WorkerIngressIpsecIke:
    Type: AWS::EC2::SecurityGroupIngress
    Properties:
      GroupId: !GetAtt WorkerSecurityGroup.GroupId
      SourceSecurityGroupId: !GetAtt WorkerSecurityGroup.GroupId
      Description: IPsec IKE packets
      FromPort: 500
      ToPort: 500
      IpProtocol: udp

  WorkerIngressIpsecNat:
    Type: AWS::EC2::SecurityGroupIngress
    Properties:
      GroupId: !GetAtt WorkerSecurityGroup.GroupId
      SourceSecurityGroupId: !GetAtt WorkerSecurityGroup.GroupId
      Description: IPsec NAT-T packets
      FromPort: 4500
      ToPort: 4500
      IpProtocol: udp

  WorkerIngressIpsecEsp:
    Type: AWS::EC2::SecurityGroupIngress
    Properties:
      GroupId: !GetAtt WorkerSecurityGroup.GroupId
      SourceSecurityGroupId: !GetAtt WorkerSecurityGroup.GroupId
      Description: IPsec ESP packets
      IpProtocol: 50

  WorkerIngressMasterIpsecIke:
    Type: AWS::EC2::SecurityGroupIngress
    Properties:
      GroupId: !GetAtt WorkerSecurityGroup.GroupId
      SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId
      Description: IPsec IKE packets
      FromPort: 500
      ToPort: 500
      IpProtocol: udp
```

```
WorkerIngressMasterIpsecNat:
  Type: AWS::EC2::SecurityGroupIngress
  Properties:
    GroupId: !GetAtt WorkerSecurityGroup.GroupId
    SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId
    Description: IPsec NAT-T packets
    FromPort: 4500
    ToPort: 4500
    IpProtocol: udp

WorkerIngressMasterIpsecEsp:
  Type: AWS::EC2::SecurityGroupIngress
  Properties:
    GroupId: !GetAtt WorkerSecurityGroup.GroupId
    SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId
    Description: IPsec ESP packets
    IpProtocol: 50

WorkerIngressInternal:
  Type: AWS::EC2::SecurityGroupIngress
  Properties:
    GroupId: !GetAtt WorkerSecurityGroup.GroupId
    SourceSecurityGroupId: !GetAtt WorkerSecurityGroup.GroupId
    Description: Internal cluster communication
    FromPort: 9000
    ToPort: 9999
    IpProtocol: tcp

WorkerIngressMasterInternal:
  Type: AWS::EC2::SecurityGroupIngress
  Properties:
    GroupId: !GetAtt WorkerSecurityGroup.GroupId
    SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId
    Description: Internal cluster communication
    FromPort: 9000
    ToPort: 9999
    IpProtocol: tcp

WorkerIngressInternalUDP:
  Type: AWS::EC2::SecurityGroupIngress
  Properties:
    GroupId: !GetAtt WorkerSecurityGroup.GroupId
    SourceSecurityGroupId: !GetAtt WorkerSecurityGroup.GroupId
    Description: Internal cluster communication
    FromPort: 9000
    ToPort: 9999
    IpProtocol: udp

WorkerIngressMasterInternalUDP:
  Type: AWS::EC2::SecurityGroupIngress
  Properties:
    GroupId: !GetAtt WorkerSecurityGroup.GroupId
    SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId
    Description: Internal cluster communication
    FromPort: 9000
    ToPort: 9999
```

```
      IpProtocol: udp

  WorkerIngressKube:
    Type: AWS::EC2::SecurityGroupIngress
    Properties:
      GroupId: !GetAtt WorkerSecurityGroup.GroupId
      SourceSecurityGroupId: !GetAtt WorkerSecurityGroup.GroupId
      Description: Kubernetes secure kubelet port
      FromPort: 10250
      ToPort: 10250
      IpProtocol: tcp

  WorkerIngressWorkerKube:
    Type: AWS::EC2::SecurityGroupIngress
    Properties:
      GroupId: !GetAtt WorkerSecurityGroup.GroupId
      SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId
      Description: Internal Kubernetes communication
      FromPort: 10250
      ToPort: 10250
      IpProtocol: tcp

  WorkerIngressIngressServices:
    Type: AWS::EC2::SecurityGroupIngress
    Properties:
      GroupId: !GetAtt WorkerSecurityGroup.GroupId
      SourceSecurityGroupId: !GetAtt WorkerSecurityGroup.GroupId
      Description: Kubernetes ingress services
      FromPort: 30000
      ToPort: 32767
      IpProtocol: tcp

  WorkerIngressMasterIngressServices:
    Type: AWS::EC2::SecurityGroupIngress
    Properties:
      GroupId: !GetAtt WorkerSecurityGroup.GroupId
      SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId
      Description: Kubernetes ingress services
      FromPort: 30000
      ToPort: 32767
      IpProtocol: tcp

  WorkerIngressIngressServicesUDP:
    Type: AWS::EC2::SecurityGroupIngress
    Properties:
      GroupId: !GetAtt WorkerSecurityGroup.GroupId
      SourceSecurityGroupId: !GetAtt WorkerSecurityGroup.GroupId
      Description: Kubernetes ingress services
      FromPort: 30000
      ToPort: 32767
      IpProtocol: udp

  WorkerIngressMasterIngressServicesUDP:
    Type: AWS::EC2::SecurityGroupIngress
    Properties:
      GroupId: !GetAtt WorkerSecurityGroup.GroupId
```

```
    SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId
    Description: Kubernetes ingress services
    FromPort: 30000
    ToPort: 32767
    IpProtocol: udp

MasterIamRole:
  Type: AWS::IAM::Role
  Properties:
    AssumeRolePolicyDocument:
      Version: "2012-10-17"
      Statement:
      - Effect: "Allow"
        Principal:
          Service:
          - "ec2.amazonaws.com"
        Action:
        - "sts:AssumeRole"
    Policies:
    - PolicyName: !Join ["-", [!Ref InfrastructureName, "master", "policy"]]
      PolicyDocument:
        Version: "2012-10-17"
        Statement:
        - Effect: "Allow"
          Action:
          - "ec2:AttachVolume"
          - "ec2:AuthorizeSecurityGroupIngress"
          - "ec2:CreateSecurityGroup"
          - "ec2:CreateTags"
          - "ec2:CreateVolume"
          - "ec2:DeleteSecurityGroup"
          - "ec2:DeleteVolume"
          - "ec2:Describe*"
          - "ec2:DetachVolume"
          - "ec2:ModifyInstanceAttribute"
          - "ec2:ModifyVolume"
          - "ec2:RevokeSecurityGroupIngress"
          - "elasticloadbalancing:AddTags"
          - "elasticloadbalancing:AttachLoadBalancerToSubnets"
          - "elasticloadbalancing:ApplySecurityGroupsToLoadBalancer"
          - "elasticloadbalancing:CreateListener"
          - "elasticloadbalancing:CreateLoadBalancer"
          - "elasticloadbalancing:CreateLoadBalancerPolicy"
          - "elasticloadbalancing:CreateLoadBalancerListeners"
          - "elasticloadbalancing:CreateTargetGroup"
          - "elasticloadbalancing:ConfigureHealthCheck"
          - "elasticloadbalancing:DeleteListener"
          - "elasticloadbalancing:DeleteLoadBalancer"
          - "elasticloadbalancing:DeleteLoadBalancerListeners"
          - "elasticloadbalancing:DeleteTargetGroup"
          - "elasticloadbalancing:DeregisterInstancesFromLoadBalancer"
          - "elasticloadbalancing:DeregisterTargets"
          - "elasticloadbalancing:Describe*"
          - "elasticloadbalancing:DetachLoadBalancerFromSubnets"
          - "elasticloadbalancing:ModifyListener"
          - "elasticloadbalancing:ModifyLoadBalancerAttributes"
```

```
            - "elasticloadbalancing:ModifyTargetGroup"
            - "elasticloadbalancing:ModifyTargetGroupAttributes"
            - "elasticloadbalancing:RegisterInstancesWithLoadBalancer"
            - "elasticloadbalancing:RegisterTargets"
            - "elasticloadbalancing:SetLoadBalancerPoliciesForBackendServer"
            - "elasticloadbalancing:SetLoadBalancerPoliciesOfListener"
            - "kms:DescribeKey"
            Resource: "*"

  MasterInstanceProfile:
    Type: "AWS::IAM::InstanceProfile"
    Properties:
      Roles:
      - Ref: "MasterIamRole"

  WorkerIamRole:
    Type: AWS::IAM::Role
    Properties:
      AssumeRolePolicyDocument:
        Version: "2012-10-17"
        Statement:
        - Effect: "Allow"
          Principal:
            Service:
            - "ec2.amazonaws.com"
          Action:
          - "sts:AssumeRole"
      Policies:
      - PolicyName: !Join ["-", [!Ref InfrastructureName, "worker", "policy"]]
        PolicyDocument:
          Version: "2012-10-17"
          Statement:
          - Effect: "Allow"
            Action:
            - "ec2:DescribeInstances"
            - "ec2:DescribeRegions"
            Resource: "*"

  WorkerInstanceProfile:
    Type: "AWS::IAM::InstanceProfile"
    Properties:
      Roles:
      - Ref: "WorkerIamRole"

Outputs:
  MasterSecurityGroupId:
    Description: Master Security Group ID
    Value: !GetAtt MasterSecurityGroup.GroupId

  WorkerSecurityGroupId:
    Description: Worker Security Group ID
    Value: !GetAtt WorkerSecurityGroup.GroupId

  MasterInstanceProfile:
    Description: Master IAM Instance Profile
    Value: !Ref MasterInstanceProfile
```

```
WorkerInstanceProfile:
  Description: Worker IAM Instance Profile
  Value: !Ref WorkerInstanceProfile
```

Additional resources

- You can view details about the CloudFormation stacks that you create by navigating to the AWS CloudFormation console.

5.13.13. Accessing RHCOS AMIs with stream metadata

In OpenShift Container Platform, *stream metadata* provides standardized metadata about RHCOS in the JSON format and injects the metadata into the cluster. Stream metadata is a stable format that supports multiple architectures and is intended to be self-documenting for maintaining automation.

You can use the **coreos print-stream-json** sub-command of **openshift-install** to access information about the boot images in the stream metadata format. This command provides a method for printing stream metadata in a scriptable, machine-readable format.

For user-provisioned installations, the **openshift-install** binary contains references to the version of RHCOS boot images that are tested for use with OpenShift Container Platform, such as the AWS AMI.

Procedure

To parse the stream metadata, use one of the following methods:

- From a Go program, use the official **stream-metadata-go** library at https://github.com/coreos/stream-metadata-go. You can also view example code in the library.
- From another programming language, such as Python or Ruby, use the JSON library of your preferred programming language.
- From a command-line utility that handles JSON data, such as **jq**:
  - Print the current **x86_64** or **aarch64** AMI for an AWS region, such as **us-west-1**:

    For x86_64

    ```
    $ openshift-install coreos print-stream-json | jq -r
    '.architectures.x86_64.images.aws.regions["us-west-1"].image'
    ```

    Example output

    ```
    ami-0d3e625f84626bbda
    ```

    For aarch64

    ```
    $ openshift-install coreos print-stream-json | jq -r
    '.architectures.aarch64.images.aws.regions["us-west-1"].image'
    ```

    Example output

```
ami-0af1d3b7fa5be2131
```

The output of this command is the AWS AMI ID for your designated architecture and the **us-west-1** region. The AMI must belong to the same region as the cluster.

5.13.14. RHCOS AMIs for the AWS infrastructure

Red Hat provides Red Hat Enterprise Linux CoreOS (RHCOS) AMIs that are valid for the various AWS regions and instance architectures that you can manually specify for your OpenShift Container Platform nodes.

NOTE

By importing your own AMI, you can also install to regions that do not have a published RHCOS AMI.

Table 5.48. x86_64 RHCOS AMIs

AWS zone	AWS AMI
af-south-1	**ami-0067394b051d857f9**
ap-east-1	**ami-057f593cc29fd3e08**
ap-northeast-1	**ami-0f5bfc3e39711a7d8**
ap-northeast-2	**ami-07b8f6b801b49a0b7**
ap-northeast-3	**ami-0677b0ba9d47e5e3a**
ap-south-1	**ami-0755c7732de0421e7**
ap-southeast-1	**ami-07b2f18a01b8ddce4**
ap-southeast-2	**ami-075b1af2bc583944b**
ap-southeast-3	**ami-0b5a81f57762da2f4**
ca-central-1	**ami-0fda98e014e64d6c4**
eu-central-1	**ami-0ba6fa5b3d81c5d56**
eu-north-1	**ami-08aed4be0d4d11b0c**
eu-south-1	**ami-0349bc626dd021c7c**
eu-west-1	**ami-0706a49df2a8357b6**

AWS zone	AWS AMI
eu-west-2	**ami-0681b7397b0ec9691**
eu-west-3	**ami-0919c4668782f35da**
me-south-1	**ami-07ef03ebf19799060**
sa-east-1	**ami-046a4e6f57aea3234**
us-east-1	**ami-0722eb0819717090f**
us-east-2	**ami-026e5701f495c94a2**
us-gov-east-1	**ami-016dce87c45add851**
us-gov-west-1	**ami-0c5bb1f0b393638a0**
us-west-1	**ami-021ef831672014a17**
us-west-2	**ami-0bba4636ff1b1dc1c**

Table 5.49. aarch64 RHCOS AMIs

AWS zone	AWS AMI
ap-east-1	**ami-083382a51b31f6bd1**
ap-northeast-1	**ami-09b84fda1b7171183**
ap-northeast-2	**ami-06404fbe4209e9557**
ap-south-1	**ami-0b9655b3c7c3525ba**
ap-southeast-1	**ami-0a9b453d016e3dfde**
ap-southeast-2	**ami-0e7af060f6e927702**
ca-central-1	**ami-0c8293928c44b6bbd**
eu-central-1	**ami-08a950d054a165e21**
eu-north-1	**ami-020dd619ad4f379dd**
eu-south-1	**ami-0b915ff416b9aad24**

AWS zone	AWS AMI
eu-west-1	**ami-034df7689a87ce826**
eu-west-2	**ami-02bf81e08b4b2f1ef**
eu-west-3	**ami-03878de77169a8599**
me-south-1	**ami-034b27bd530bac050**
sa-east-1	**ami-06ab90bd7daf4dd8b**
us-east-1	**ami-00d3196d06bc2a924**
us-east-2	**ami-028a3d23312630036**
us-west-1	**ami-05356b8fece665cf1**
us-west-2	**ami-0e6473997df31eb0f**

5.13.14.1. AWS regions without a published RHCOS AMI

You can deploy an OpenShift Container Platform cluster to Amazon Web Services (AWS) regions without native support for a Red Hat Enterprise Linux CoreOS (RHCOS) Amazon Machine Image (AMI) or the AWS software development kit (SDK). If a published AMI is not available for an AWS region, you can upload a custom AMI prior to installing the cluster.

If you are deploying to a region not supported by the AWS SDK and you do not specify a custom AMI, the installation program copies the **us-east-1** AMI to the user account automatically. Then the installation program creates the control plane machines with encrypted EBS volumes using the default or user-specified Key Management Service (KMS) key. This allows the AMI to follow the same process workflow as published RHCOS AMIs.

A region without native support for an RHCOS AMI is not available to select from the terminal during cluster creation because it is not published. However, you can install to this region by configuring the custom AMI in the **install-config.yaml** file.

5.13.14.2. Uploading a custom RHCOS AMI in AWS

If you are deploying to a custom Amazon Web Services (AWS) region, you must upload a custom Red Hat Enterprise Linux CoreOS (RHCOS) Amazon Machine Image (AMI) that belongs to that region.

Prerequisites

- You configured an AWS account.
- You created an Amazon S3 bucket with the required IAM service role.
- You uploaded your RHCOS VMDK file to Amazon S3. The RHCOS VMDK file must be the highest version that is less than or equal to the OpenShift Container Platform version you are installing.

- You downloaded the AWS CLI and installed it on your computer. See Install the AWS CLI Using the Bundled Installer.

Procedure

1. Export your AWS profile as an environment variable:

```
$ export AWS_PROFILE=<aws_profile> 1
```

2. Export the region to associate with your custom AMI as an environment variable:

```
$ export AWS_DEFAULT_REGION=<aws_region> 1
```

3. Export the version of RHCOS you uploaded to Amazon S3 as an environment variable:

```
$ export RHCOS_VERSION=<version> 1
```

1 1 1 The RHCOS VMDK version, like **4.11.0**.

4. Export the Amazon S3 bucket name as an environment variable:

```
$ export VMIMPORT_BUCKET_NAME=<s3_bucket_name>
```

5. Create the **containers.json** file and define your RHCOS VMDK file:

```
$ cat <<EOF > containers.json
{
  "Description": "rhcos-${RHCOS_VERSION}-x86_64-aws.x86_64",
  "Format": "vmdk",
  "UserBucket": {
    "S3Bucket": "${VMIMPORT_BUCKET_NAME}",
    "S3Key": "rhcos-${RHCOS_VERSION}-x86_64-aws.x86_64.vmdk"
  }
}
EOF
```

6. Import the RHCOS disk as an Amazon EBS snapshot:

```
$ aws ec2 import-snapshot --region ${AWS_DEFAULT_REGION} \
    --description "<description>" \ 1
    --disk-container "file://<file_path>/containers.json" 2
```

1 The description of your RHCOS disk being imported, like **rhcos-${RHCOS_VERSION}-x86_64-aws.x86_64**.

2 The file path to the JSON file describing your RHCOS disk. The JSON file should contain your Amazon S3 bucket name and key.

7. Check the status of the image import:

```
$ watch -n 5 aws ec2 describe-import-snapshot-tasks --region ${AWS_DEFAULT_REGION}
```

Example output

```
{
    "ImportSnapshotTasks": [
        {
            "Description": "rhcos-4.7.0-x86_64-aws.x86_64",
            "ImportTaskId": "import-snap-fh6i8uil",
            "SnapshotTaskDetail": {
                "Description": "rhcos-4.7.0-x86_64-aws.x86_64",
                "DiskImageSize": 819056640.0,
                "Format": "VMDK",
                "SnapshotId": "snap-06331325870076318",
                "Status": "completed",
                "UserBucket": {
                    "S3Bucket": "external-images",
                    "S3Key": "rhcos-4.7.0-x86_64-aws.x86_64.vmdk"
                }
            }
        }
    ]
}
```

Copy the **SnapshotId** to register the image.

8. Create a custom RHCOS AMI from the RHCOS snapshot:

```
$ aws ec2 register-image \
  --region ${AWS_DEFAULT_REGION} \
  --architecture x86_64 \ 1
  --description "rhcos-${RHCOS_VERSION}-x86_64-aws.x86_64" \ 2
  --ena-support \
  --name "rhcos-${RHCOS_VERSION}-x86_64-aws.x86_64" \ 3
  --virtualization-type hvm \
  --root-device-name '/dev/xvda' \
  --block-device-mappings 'DeviceName=/dev/xvda,Ebs=
{DeleteOnTermination=true,SnapshotId=<snapshot_ID>}' 4
```

1. The RHCOS VMDK architecture type, like **x86_64**, **aarch64**, **s390x**, or **ppc64le**.
2. The **Description** from the imported snapshot.
3. The name of the RHCOS AMI.
4. The **SnapshotID** from the imported snapshot.

To learn more about these APIs, see the AWS documentation for importing snapshots and creating EBS-backed AMIs.

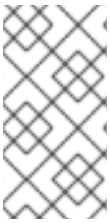
5.13.15. Creating the bootstrap node in AWS

You must create the bootstrap node in Amazon Web Services (AWS) to use during OpenShift Container Platform cluster initialization. You do this by:

- Providing a location to serve the **bootstrap.ign** Ignition config file to your cluster. This file is

located in your installation directory. The provided CloudFormation Template assumes that the Ignition config files for your cluster are served from an S3 bucket. If you choose to serve the files from another location, you must modify the templates.

- Using the provided CloudFormation template and a custom parameter file to create a stack of AWS resources. The stack represents the bootstrap node that your OpenShift Container Platform installation requires.



NOTE

If you do not use the provided CloudFormation template to create your bootstrap node, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

Prerequisites

- You configured an AWS account.
- You added your AWS keys and region to your local AWS profile by running **aws configure**.
- You generated the Ignition config files for your cluster.
- You created and configured a VPC and associated subnets in AWS.
- You created and configured DNS, load balancers, and listeners in AWS.
- You created the security groups and roles required for your cluster in AWS.

Procedure

1. Create the bucket by running the following command:

```
$ aws s3 mb s3://<cluster-name>-infra 1
```

1 **<cluster-name>-infra** is the bucket name. When creating the **install-config.yaml** file, replace **<cluster-name>** with the name specified for the cluster.

You must use a presigned URL for your S3 bucket, instead of the **s3://** schema, if you are:

- Deploying to a region that has endpoints that differ from the AWS SDK.
- Deploying a proxy.
- Providing your own custom endpoints.

2. Upload the **bootstrap.ign** Ignition config file to the bucket by running the following command:

```
$ aws s3 cp <installation_directory>/bootstrap.ign s3://<cluster-name>-infra/bootstrap.ign 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

3. Verify that the file uploaded by running the following command:

```
$ aws s3 ls s3://<cluster-name>-infra/
```

Example output

```
2019-04-03 16:15:16     314878 bootstrap.ign
```

NOTE

The bootstrap Ignition config file does contain secrets, like X.509 keys. The following steps provide basic security for the S3 bucket. To provide additional security, you can enable an S3 bucket policy to allow only certain users, such as the OpenShift IAM user, to access objects that the bucket contains. You can avoid S3 entirely and serve your bootstrap Ignition config file from any address that the bootstrap machine can reach.

4. Create a JSON file that contains the parameter values that the template requires:

```
[
  {
    "ParameterKey": "InfrastructureName", 1
    "ParameterValue": "mycluster-<random_string>" 2
  },
  {
    "ParameterKey": "RhcosAmi", 3
    "ParameterValue": "ami-<random_string>" 4
  },
  {
    "ParameterKey": "AllowedBootstrapSshCidr", 5
    "ParameterValue": "0.0.0.0/0" 6
  },
  {
    "ParameterKey": "PublicSubnet", 7
    "ParameterValue": "subnet-<random_string>" 8
  },
  {
    "ParameterKey": "MasterSecurityGroupId", 9
    "ParameterValue": "sg-<random_string>" 10
  },
  {
    "ParameterKey": "VpcId", 11
    "ParameterValue": "vpc-<random_string>" 12
  },
  {
    "ParameterKey": "BootstrapIgnitionLocation", 13
    "ParameterValue": "s3://<bucket_name>/bootstrap.ign" 14
  },
  {
    "ParameterKey": "AutoRegisterELB", 15
    "ParameterValue": "yes" 16
  },
  {
    "ParameterKey": "RegisterNlbIpTargetsLambdaArn", 17
```

```
    "ParameterValue": "arn:aws:lambda:<region>:<account_number>:function:
<dns_stack_name>-RegisterNlbIpTargets-<random_string>" 18
  },
  {
    "ParameterKey": "ExternalApiTargetGroupArn", 19
    "ParameterValue": "arn:aws:elasticloadbalancing:<region>:
<account_number>:targetgroup/<dns_stack_name>-Exter-<random_string>" 20
  },
  {
    "ParameterKey": "InternalApiTargetGroupArn", 21
    "ParameterValue": "arn:aws:elasticloadbalancing:<region>:
<account_number>:targetgroup/<dns_stack_name>-Inter-<random_string>" 22
  },
  {
    "ParameterKey": "InternalServiceTargetGroupArn", 23
    "ParameterValue": "arn:aws:elasticloadbalancing:<region>:
<account_number>:targetgroup/<dns_stack_name>-Inter-<random_string>" 24
  }
]
```

1. The name for your cluster infrastructure that is encoded in your Ignition config files for the cluster.
2. Specify the infrastructure name that you extracted from the Ignition config file metadata, which has the format **<cluster-name>-<random-string>**.
3. Current Red Hat Enterprise Linux CoreOS (RHCOS) AMI to use for the bootstrap node based on your selected architecture.
4. Specify a valid **AWS::EC2::Image::Id** value.
5. CIDR block to allow SSH access to the bootstrap node.
6. Specify a CIDR block in the format **x.x.x.x/16-24**.
7. The public subnet that is associated with your VPC to launch the bootstrap node into.
8. Specify the **PublicSubnetIds** value from the output of the CloudFormation template for the VPC.
9. The master security group ID (for registering temporary rules)
10. Specify the **MasterSecurityGroupId** value from the output of the CloudFormation template for the security group and roles.
11. The VPC created resources will belong to.
12. Specify the **VpcId** value from the output of the CloudFormation template for the VPC.
13. Location to fetch bootstrap Ignition config file from.
14. Specify the S3 bucket and file name in the form **s3://<bucket_name>/bootstrap.ign**.
15. Whether or not to register a network load balancer (NLB).
16. Specify **yes** or **no**. If you specify **yes**, you must provide a Lambda Amazon Resource Name (ARN) value

(ARN) value.

17 The ARN for NLB IP target registration lambda group.

18 Specify the **RegisterNlbIpTargetsLambda** value from the output of the CloudFormation template for DNS and load balancing. Use **arn:aws-us-gov** if deploying the cluster to an AWS GovCloud region.

19 The ARN for external API load balancer target group.

20 Specify the **ExternalApiTargetGroupArn** value from the output of the CloudFormation template for DNS and load balancing. Use **arn:aws-us-gov** if deploying the cluster to an AWS GovCloud region.

21 The ARN for internal API load balancer target group.

22 Specify the **InternalApiTargetGroupArn** value from the output of the CloudFormation template for DNS and load balancing. Use **arn:aws-us-gov** if deploying the cluster to an AWS GovCloud region.

23 The ARN for internal service load balancer target group.

24 Specify the **InternalServiceTargetGroupArn** value from the output of the CloudFormation template for DNS and load balancing. Use **arn:aws-us-gov** if deploying the cluster to an AWS GovCloud region.

5. Copy the template from the **CloudFormation template for the bootstrap machine**section of this topic and save it as a YAML file on your computer. This template describes the bootstrap machine that your cluster requires.

6. Optional: If you are deploying the cluster with a proxy, you must update the ignition in the template to add the **ignition.config.proxy** fields. Additionally, If you have added the Amazon EC2, Elastic Load Balancing, and S3 VPC endpoints to your VPC, you must add these endpoints to the **noProxy** field.

7. Launch the CloudFormation template to create a stack of AWS resources that represent the bootstrap node:

IMPORTANT

You must enter the command on a single line.

```
$ aws cloudformation create-stack --stack-name <name> 1
    --template-body file://<template>.yaml 2
    --parameters file://<parameters>.json 3
    --capabilities CAPABILITY_NAMED_IAM 4
```

1 **<name>** is the name for the CloudFormation stack, such as **cluster-bootstrap**. You need the name of this stack if you remove the cluster.

2 **<template>** is the relative path to and name of the CloudFormation template YAML file that you saved.

3 **<parameters>** is the relative path to and name of the CloudFormation parameters JSON file.

4 You must explicitly declare the **CAPABILITY_NAMED_IAM** capability because the provided template creates some **AWS::IAM::Role** and **AWS::IAM::InstanceProfile**

Example output

```
arn:aws:cloudformation:us-east-1:269333783861:stack/cluster-bootstrap/12944486-2add-11eb-9dee-12dace8e3a83
```

8. Confirm that the template components exist:

```
$ aws cloudformation describe-stacks --stack-name <name>
```

After the **StackStatus** displays **CREATE_COMPLETE**, the output displays values for the following parameters. You must provide these parameter values to the other CloudFormation templates that you run to create your cluster:

Bootstrap InstanceId	The bootstrap Instance ID.
Bootstrap PublicIp	The bootstrap node public IP address.
Bootstrap PrivateIp	The bootstrap node private IP address.

5.13.15.1. CloudFormation template for the bootstrap machine

You can use the following CloudFormation template to deploy the bootstrap machine that you need for your OpenShift Container Platform cluster.

Example 5.47. CloudFormation template for the bootstrap machine

```
AWSTemplateFormatVersion: 2010-09-09
Description: Template for OpenShift Cluster Bootstrap (EC2 Instance, Security Groups and IAM)

Parameters:
  InfrastructureName:
    AllowedPattern: ^([a-zA-Z][a-zA-Z0-9\-]{0,26})$
    MaxLength: 27
    MinLength: 1
    ConstraintDescription: Infrastructure name must be alphanumeric, start with a letter, and have a maximum of 27 characters.
    Description: A short, unique cluster ID used to tag cloud resources and identify items owned or used by the cluster.
    Type: String
  RhcosAmi:
    Description: Current Red Hat Enterprise Linux CoreOS AMI to use for bootstrap.
    Type: AWS::EC2::Image::Id
  AllowedBootstrapSshCidr:
    AllowedPattern: ^(([0-9]|[1-9][0-9]|1[0-9]{2}|2[0-4][0-9]|25[0-5])\.){3}([0-9]|[1-9][0-9]|1[0-9]{2}|2[0-4][0-9]|25[0-5])(\/([0-9]|1[0-9]|2[0-9]|3[0-2]))$
    ConstraintDescription: CIDR block parameter must be in the form x.x.x.x/0-32.
```

```
    Default: 0.0.0.0/0
    Description: CIDR block to allow SSH access to the bootstrap node.
    Type: String
  PublicSubnet:
    Description: The public subnet to launch the bootstrap node into.
    Type: AWS::EC2::Subnet::Id
  MasterSecurityGroupId:
    Description: The master security group ID for registering temporary rules.
    Type: AWS::EC2::SecurityGroup::Id
  VpcId:
    Description: The VPC-scoped resources will belong to this VPC.
    Type: AWS::EC2::VPC::Id
  BootstrapIgnitionLocation:
    Default: s3://my-s3-bucket/bootstrap.ign
    Description: Ignition config file location.
    Type: String
  AutoRegisterELB:
    Default: "yes"
    AllowedValues:
    - "yes"
    - "no"
    Description: Do you want to invoke NLB registration, which requires a Lambda ARN parameter?
    Type: String
  RegisterNlbIpTargetsLambdaArn:
    Description: ARN for NLB IP target registration lambda.
    Type: String
  ExternalApiTargetGroupArn:
    Description: ARN for external API load balancer target group.
    Type: String
  InternalApiTargetGroupArn:
    Description: ARN for internal API load balancer target group.
    Type: String
  InternalServiceTargetGroupArn:
    Description: ARN for internal service load balancer target group.
    Type: String
  BootstrapInstanceType:
    Description: Instance type for the bootstrap EC2 instance
    Default: "i3.large"
    Type: String

Metadata:
  AWS::CloudFormation::Interface:
    ParameterGroups:
    - Label:
        default: "Cluster Information"
      Parameters:
      - InfrastructureName
    - Label:
        default: "Host Information"
      Parameters:
      - RhcosAmi
      - BootstrapIgnitionLocation
      - MasterSecurityGroupId
    - Label:
        default: "Network Configuration"
      Parameters:
```

```
      - VpcId
      - AllowedBootstrapSshCidr
      - PublicSubnet
    - Label:
        default: "Load Balancer Automation"
      Parameters:
      - AutoRegisterELB
      - RegisterNlbIpTargetsLambdaArn
      - ExternalApiTargetGroupArn
      - InternalApiTargetGroupArn
      - InternalServiceTargetGroupArn
    ParameterLabels:
      InfrastructureName:
        default: "Infrastructure Name"
      VpcId:
        default: "VPC ID"
      AllowedBootstrapSshCidr:
        default: "Allowed SSH Source"
      PublicSubnet:
        default: "Public Subnet"
      RhcosAmi:
        default: "Red Hat Enterprise Linux CoreOS AMI ID"
      BootstrapIgnitionLocation:
        default: "Bootstrap Ignition Source"
      MasterSecurityGroupId:
        default: "Master Security Group ID"
      AutoRegisterELB:
        default: "Use Provided ELB Automation"

Conditions:
  DoRegistration: !Equals ["yes", !Ref AutoRegisterELB]

Resources:
  BootstrapIamRole:
    Type: AWS::IAM::Role
    Properties:
      AssumeRolePolicyDocument:
        Version: "2012-10-17"
        Statement:
        - Effect: "Allow"
          Principal:
            Service:
            - "ec2.amazonaws.com"
          Action:
          - "sts:AssumeRole"
      Path: "/"
      Policies:
      - PolicyName: !Join ["-", [!Ref InfrastructureName, "bootstrap", "policy"]]
        PolicyDocument:
          Version: "2012-10-17"
          Statement:
          - Effect: "Allow"
            Action: "ec2:Describe*"
            Resource: "*"
          - Effect: "Allow"
            Action: "ec2:AttachVolume"
```

```
          Resource: "*"
        - Effect: "Allow"
          Action: "ec2:DetachVolume"
          Resource: "*"
        - Effect: "Allow"
          Action: "s3:GetObject"
          Resource: "*"

BootstrapInstanceProfile:
  Type: "AWS::IAM::InstanceProfile"
  Properties:
    Path: "/"
    Roles:
    - Ref: "BootstrapIamRole"

BootstrapSecurityGroup:
  Type: AWS::EC2::SecurityGroup
  Properties:
    GroupDescription: Cluster Bootstrap Security Group
    SecurityGroupIngress:
    - IpProtocol: tcp
      FromPort: 22
      ToPort: 22
      CidrIp: !Ref AllowedBootstrapSshCidr
    - IpProtocol: tcp
      ToPort: 19531
      FromPort: 19531
      CidrIp: 0.0.0.0/0
    VpcId: !Ref VpcId

BootstrapInstance:
  Type: AWS::EC2::Instance
  Properties:
    ImageId: !Ref RhcosAmi
    IamInstanceProfile: !Ref BootstrapInstanceProfile
    InstanceType: !Ref BootstrapInstanceType
    NetworkInterfaces:
    - AssociatePublicIpAddress: "true"
      DeviceIndex: "0"
      GroupSet:
      - !Ref "BootstrapSecurityGroup"
      - !Ref "MasterSecurityGroupId"
      SubnetId: !Ref "PublicSubnet"
    UserData:
      Fn::Base64: !Sub
      - '{"ignition":{"config":{"replace":{"source":"${S3Loc}"}},"version":"3.1.0"}}'
      - {
        S3Loc: !Ref BootstrapIgnitionLocation
      }

RegisterBootstrapApiTarget:
  Condition: DoRegistration
  Type: Custom::NLBRegister
  Properties:
    ServiceToken: !Ref RegisterNlbIpTargetsLambdaArn
    TargetArn: !Ref ExternalApiTargetGroupArn
```

```
      TargetIp: !GetAtt BootstrapInstance.PrivateIp

  RegisterBootstrapInternalApiTarget:
    Condition: DoRegistration
    Type: Custom::NLBRegister
    Properties:
      ServiceToken: !Ref RegisterNlbIpTargetsLambdaArn
      TargetArn: !Ref InternalApiTargetGroupArn
      TargetIp: !GetAtt BootstrapInstance.PrivateIp

  RegisterBootstrapInternalServiceTarget:
    Condition: DoRegistration
    Type: Custom::NLBRegister
    Properties:
      ServiceToken: !Ref RegisterNlbIpTargetsLambdaArn
      TargetArn: !Ref InternalServiceTargetGroupArn
      TargetIp: !GetAtt BootstrapInstance.PrivateIp

Outputs:
  BootstrapInstanceId:
    Description: Bootstrap Instance ID.
    Value: !Ref BootstrapInstance

  BootstrapPublicIp:
    Description: The bootstrap node public IP address.
    Value: !GetAtt BootstrapInstance.PublicIp

  BootstrapPrivateIp:
    Description: The bootstrap node private IP address.
    Value: !GetAtt BootstrapInstance.PrivateIp
```

Additional resources

- You can view details about the CloudFormation stacks that you create by navigating to the AWS CloudFormation console.
- See RHCOS AMIs for the AWS infrastructure for details about the Red Hat Enterprise Linux CoreOS (RHCOS) AMIs for the AWS zones.

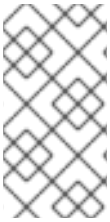
5.13.16. Creating the control plane machines in AWS

You must create the control plane machines in Amazon Web Services (AWS) that your cluster will use.

You can use the provided CloudFormation template and a custom parameter file to create a stack of AWS resources that represent the control plane nodes.

IMPORTANT

The CloudFormation template creates a stack that represents three control plane nodes.



NOTE

If you do not use the provided CloudFormation template to create your control plane nodes, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

Prerequisites

- You configured an AWS account.
- You added your AWS keys and region to your local AWS profile by running **aws configure**.
- You generated the Ignition config files for your cluster.
- You created and configured a VPC and associated subnets in AWS.
- You created and configured DNS, load balancers, and listeners in AWS.
- You created the security groups and roles required for your cluster in AWS.
- You created the bootstrap machine.

Procedure

1. Create a JSON file that contains the parameter values that the template requires:

```
[
  {
    "ParameterKey": "InfrastructureName", 1
    "ParameterValue": "mycluster-<random_string>" 2
  },
  {
    "ParameterKey": "RhcosAmi", 3
    "ParameterValue": "ami-<random_string>" 4
  },
  {
    "ParameterKey": "AutoRegisterDNS", 5
    "ParameterValue": "yes" 6
  },
  {
    "ParameterKey": "PrivateHostedZoneId", 7
    "ParameterValue": "<random_string>" 8
  },
  {
    "ParameterKey": "PrivateHostedZoneName", 9
    "ParameterValue": "mycluster.example.com" 10
  },
  {
    "ParameterKey": "Master0Subnet", 11
    "ParameterValue": "subnet-<random_string>" 12
  },
  {
    "ParameterKey": "Master1Subnet", 13
```

```
    "ParameterValue": "subnet-<random_string>" 14
  },
  {
    "ParameterKey": "Master2Subnet", 15
    "ParameterValue": "subnet-<random_string>" 16
  },
  {
    "ParameterKey": "MasterSecurityGroupId", 17
    "ParameterValue": "sg-<random_string>" 18
  },
  {
    "ParameterKey": "IgnitionLocation", 19
    "ParameterValue": "https://api-int.<cluster_name>.<domain_name>:22623/config/master"
20
  },
  {
    "ParameterKey": "CertificateAuthorities", 21
    "ParameterValue": "data:text/plain;charset=utf-8;base64,ABC...xYz==" 22
  },
  {
    "ParameterKey": "MasterInstanceProfileName", 23
    "ParameterValue": "<roles_stack>-MasterInstanceProfile-<random_string>" 24
  },
  {
    "ParameterKey": "MasterInstanceType", 25
    "ParameterValue": "" 26
  },
  {
    "ParameterKey": "AutoRegisterELB", 27
    "ParameterValue": "yes" 28
  },
  {
    "ParameterKey": "RegisterNlbIpTargetsLambdaArn", 29
    "ParameterValue": "arn:aws:lambda:<region>:<account_number>:function:
<dns_stack_name>-RegisterNlbIpTargets-<random_string>" 30
  },
  {
    "ParameterKey": "ExternalApiTargetGroupArn", 31
    "ParameterValue": "arn:aws:elasticloadbalancing:<region>:
<account_number>:targetgroup/<dns_stack_name>-Exter-<random_string>" 32
  },
  {
    "ParameterKey": "InternalApiTargetGroupArn", 33
    "ParameterValue": "arn:aws:elasticloadbalancing:<region>:
<account_number>:targetgroup/<dns_stack_name>-Inter-<random_string>" 34
  },
  {
    "ParameterKey": "InternalServiceTargetGroupArn", 35
    "ParameterValue": "arn:aws:elasticloadbalancing:<region>:
<account_number>:targetgroup/<dns_stack_name>-Inter-<random_string>" 36
  }
]
```

1. The name for your cluster infrastructure that is encoded in your Ignition config files for the cluster.
2. Specify the infrastructure name that you extracted from the Ignition config file metadata, which has the format **<cluster-name>-<random-string>**.
3. Current Red Hat Enterprise Linux CoreOS (RHCOS) AMI to use for the control plane machines based on your selected architecture.
4. Specify an **AWS::EC2::Image::Id** value.
5. Whether or not to perform DNS etcd registration.
6. Specify **yes** or **no**. If you specify **yes**, you must provide hosted zone information.
7. The Route 53 private zone ID to register the etcd targets with.
8. Specify the **PrivateHostedZoneId** value from the output of the CloudFormation template for DNS and load balancing.
9. The Route 53 zone to register the targets with.
10. Specify **<cluster_name>.<domain_name>** where **<domain_name>** is the Route 53 base domain that you used when you generated **install-config.yaml** file for the cluster. Do not include the trailing period (.) that is displayed in the AWS console.
11. 13. 15. A subnet, preferably private, to launch the control plane machines on.
12. 14. 16. Specify a subnet from the **PrivateSubnets** value from the output of the CloudFormation template for DNS and load balancing.
17. The master security group ID to associate with control plane nodes.
18. Specify the **MasterSecurityGroupId** value from the output of the CloudFormation template for the security group and roles.
19. The location to fetch control plane Ignition config file from.
20. Specify the generated Ignition config file location, **https://api-int.<cluster_name>.<domain_name>:22623/config/master**.
21. The base64 encoded certificate authority string to use.
22. Specify the value from the **master.ign** file that is in the installation directory. This value is the long string with the format **data:text/plain;charset=utf-8;base64,ABC…xYz==**.
23. The IAM profile to associate with control plane nodes.
24. Specify the **MasterInstanceProfile** parameter value from the output of the CloudFormation template for the security group and roles.
25. The type of AWS instance to use for the control plane machines based on your selected architecture.
26. The instance type value corresponds to the minimum resource requirements for control plane machines. For example **m6i.xlarge** is a type for AMD64. and **m6g.xlarge** is a type for ARM64.

27 Whether or not to register a network load balancer (NLB).

28 Specify **yes** or **no**. If you specify **yes**, you must provide a Lambda Amazon Resource Name (ARN) value.

29 The ARN for NLB IP target registration lambda group.

30 Specify the **RegisterNlbIpTargetsLambda** value from the output of the CloudFormation template for DNS and load balancing. Use **arn:aws-us-gov** if deploying the cluster to an AWS GovCloud region.

31 The ARN for external API load balancer target group.

32 Specify the **ExternalApiTargetGroupArn** value from the output of the CloudFormation template for DNS and load balancing. Use **arn:aws-us-gov** if deploying the cluster to an AWS GovCloud region.

33 The ARN for internal API load balancer target group.

34 Specify the **InternalApiTargetGroupArn** value from the output of the CloudFormation template for DNS and load balancing. Use **arn:aws-us-gov** if deploying the cluster to an AWS GovCloud region.

35 The ARN for internal service load balancer target group.

36 Specify the **InternalServiceTargetGroupArn** value from the output of the CloudFormation template for DNS and load balancing. Use **arn:aws-us-gov** if deploying the cluster to an AWS GovCloud region.

2. Copy the template from the **CloudFormation template for control plane machines**section of this topic and save it as a YAML file on your computer. This template describes the control plane machines that your cluster requires.

3. If you specified an **m5** instance type as the value for **MasterInstanceType**, add that instance type to the **MasterInstanceType.AllowedValues** parameter in the CloudFormation template.

4. Launch the CloudFormation template to create a stack of AWS resources that represent the control plane nodes:

IMPORTANT

You must enter the command on a single line.

```
$ aws cloudformation create-stack --stack-name <name> 1
    --template-body file://<template>.yaml 2
    --parameters file://<parameters>.json 3
```

1 **<name>** is the name for the CloudFormation stack, such as **cluster-control-plane**. You need the name of this stack if you remove the cluster.

2 **<template>** is the relative path to and name of the CloudFormation template YAML file that you saved.

3 **<parameters>** is the relative path to and name of the CloudFormation parameters JSON

Example output

```
arn:aws:cloudformation:us-east-1:269333783861:stack/cluster-control-plane/21c7e2b0-2ee2-11eb-c6f6-0aa34627df4b
```

NOTE

The CloudFormation template creates a stack that represents three control plane nodes.

5. Confirm that the template components exist:

```
$ aws cloudformation describe-stacks --stack-name <name>
```

5.13.16.1. CloudFormation template for control plane machines

You can use the following CloudFormation template to deploy the control plane machines that you need for your OpenShift Container Platform cluster.

Example 5.48. CloudFormation template for control plane machines

```
AWSTemplateFormatVersion: 2010-09-09
Description: Template for OpenShift Cluster Node Launch (EC2 master instances)

Parameters:
  InfrastructureName:
    AllowedPattern: ^([a-zA-Z][a-zA-Z0-9\-]{0,26})$
    MaxLength: 27
    MinLength: 1
    ConstraintDescription: Infrastructure name must be alphanumeric, start with a letter, and have a maximum of 27 characters.
    Description: A short, unique cluster ID used to tag nodes for the kubelet cloud provider.
    Type: String
  RhcosAmi:
    Description: Current Red Hat Enterprise Linux CoreOS AMI to use for bootstrap.
    Type: AWS::EC2::Image::Id
  AutoRegisterDNS:
    Default: ""
    Description: unused
    Type: String
  PrivateHostedZoneId:
    Default: ""
    Description: unused
    Type: String
  PrivateHostedZoneName:
    Default: ""
    Description: unused
    Type: String
  Master0Subnet:
    Description: The subnets, recommend private, to launch the master nodes into.
    Type: AWS::EC2::Subnet::Id
  Master1Subnet:
    Description: The subnets, recommend private, to launch the master nodes into.
```

```
    Type: AWS::EC2::Subnet::Id
  Master2Subnet:
    Description: The subnets, recommend private, to launch the master nodes into.
    Type: AWS::EC2::Subnet::Id
  MasterSecurityGroupId:
    Description: The master security group ID to associate with master nodes.
    Type: AWS::EC2::SecurityGroup::Id
  IgnitionLocation:
    Default: https://api-int.$CLUSTER_NAME.$DOMAIN:22623/config/master
    Description: Ignition config file location.
    Type: String
  CertificateAuthorities:
    Default: data:text/plain;charset=utf-8;base64,ABC...xYz==
    Description: Base64 encoded certificate authority string to use.
    Type: String
  MasterInstanceProfileName:
    Description: IAM profile to associate with master nodes.
    Type: String
  MasterInstanceType:
    Default: m5.xlarge
    Type: String

  AutoRegisterELB:
    Default: "yes"
    AllowedValues:
    - "yes"
    - "no"
    Description: Do you want to invoke NLB registration, which requires a Lambda ARN parameter?
    Type: String
  RegisterNlbIpTargetsLambdaArn:
    Description: ARN for NLB IP target registration lambda. Supply the value from the cluster
infrastructure or select "no" for AutoRegisterELB.
    Type: String
  ExternalApiTargetGroupArn:
    Description: ARN for external API load balancer target group. Supply the value from the cluster
infrastructure or select "no" for AutoRegisterELB.
    Type: String
  InternalApiTargetGroupArn:
    Description: ARN for internal API load balancer target group. Supply the value from the cluster
infrastructure or select "no" for AutoRegisterELB.
    Type: String
  InternalServiceTargetGroupArn:
    Description: ARN for internal service load balancer target group. Supply the value from the
cluster infrastructure or select "no" for AutoRegisterELB.
    Type: String

Metadata:
  AWS::CloudFormation::Interface:
    ParameterGroups:
    - Label:
        default: "Cluster Information"
      Parameters:
      - InfrastructureName
    - Label:
        default: "Host Information"
      Parameters:
```

```
      - MasterInstanceType
      - RhcosAmi
      - IgnitionLocation
      - CertificateAuthorities
      - MasterSecurityGroupId
      - MasterInstanceProfileName
    - Label:
        default: "Network Configuration"
      Parameters:
      - VpcId
      - AllowedBootstrapSshCidr
      - Master0Subnet
      - Master1Subnet
      - Master2Subnet
    - Label:
        default: "Load Balancer Automation"
      Parameters:
      - AutoRegisterELB
      - RegisterNlbIpTargetsLambdaArn
      - ExternalApiTargetGroupArn
      - InternalApiTargetGroupArn
      - InternalServiceTargetGroupArn
    ParameterLabels:
      InfrastructureName:
        default: "Infrastructure Name"
      VpcId:
        default: "VPC ID"
      Master0Subnet:
        default: "Master-0 Subnet"
      Master1Subnet:
        default: "Master-1 Subnet"
      Master2Subnet:
        default: "Master-2 Subnet"
      MasterInstanceType:
        default: "Master Instance Type"
      MasterInstanceProfileName:
        default: "Master Instance Profile Name"
      RhcosAmi:
        default: "Red Hat Enterprise Linux CoreOS AMI ID"
      BootstrapIgnitionLocation:
        default: "Master Ignition Source"
      CertificateAuthorities:
        default: "Ignition CA String"
      MasterSecurityGroupId:
        default: "Master Security Group ID"
      AutoRegisterELB:
        default: "Use Provided ELB Automation"

Conditions:
  DoRegistration: !Equals ["yes", !Ref AutoRegisterELB]

Resources:
  Master0:
    Type: AWS::EC2::Instance
    Properties:
      ImageId: !Ref RhcosAmi
```

```
      BlockDeviceMappings:
      - DeviceName: /dev/xvda
        Ebs:
          VolumeSize: "120"
          VolumeType: "gp2"
      IamInstanceProfile: !Ref MasterInstanceProfileName
      InstanceType: !Ref MasterInstanceType
      NetworkInterfaces:
      - AssociatePublicIpAddress: "false"
        DeviceIndex: "0"
        GroupSet:
        - !Ref "MasterSecurityGroupId"
        SubnetId: !Ref "Master0Subnet"
      UserData:
        Fn::Base64: !Sub
        - '{"ignition":{"config":{"merge":[{"source":"${SOURCE}"}]},"security":{"tls":
{"certificateAuthorities":[{"source":"${CA_BUNDLE}"}]}},"version":"3.1.0"}}'
        - {
          SOURCE: !Ref IgnitionLocation,
          CA_BUNDLE: !Ref CertificateAuthorities,
        }
      Tags:
      - Key: !Join ["", ["kubernetes.io/cluster/", !Ref InfrastructureName]]
        Value: "shared"

  RegisterMaster0:
    Condition: DoRegistration
    Type: Custom::NLBRegister
    Properties:
      ServiceToken: !Ref RegisterNlbIpTargetsLambdaArn
      TargetArn: !Ref ExternalApiTargetGroupArn
      TargetIp: !GetAtt Master0.PrivateIp

  RegisterMaster0InternalApiTarget:
    Condition: DoRegistration
    Type: Custom::NLBRegister
    Properties:
      ServiceToken: !Ref RegisterNlbIpTargetsLambdaArn
      TargetArn: !Ref InternalApiTargetGroupArn
      TargetIp: !GetAtt Master0.PrivateIp

  RegisterMaster0InternalServiceTarget:
    Condition: DoRegistration
    Type: Custom::NLBRegister
    Properties:
      ServiceToken: !Ref RegisterNlbIpTargetsLambdaArn
      TargetArn: !Ref InternalServiceTargetGroupArn
      TargetIp: !GetAtt Master0.PrivateIp

  Master1:
    Type: AWS::EC2::Instance
    Properties:
      ImageId: !Ref RhcosAmi
      BlockDeviceMappings:
      - DeviceName: /dev/xvda
        Ebs:
```

```
          VolumeSize: "120"
          VolumeType: "gp2"
      IamInstanceProfile: !Ref MasterInstanceProfileName
      InstanceType: !Ref MasterInstanceType
      NetworkInterfaces:
      - AssociatePublicIpAddress: "false"
        DeviceIndex: "0"
        GroupSet:
        - !Ref "MasterSecurityGroupId"
        SubnetId: !Ref "Master1Subnet"
      UserData:
        Fn::Base64: !Sub
        - '{"ignition":{"config":{"merge":[{"source":"${SOURCE}"}]},"security":{"tls":
{"certificateAuthorities":[{"source":"${CA_BUNDLE}"}]}},"version":"3.1.0"}}'
        - {
          SOURCE: !Ref IgnitionLocation,
          CA_BUNDLE: !Ref CertificateAuthorities,
        }
      Tags:
      - Key: !Join ["", ["kubernetes.io/cluster/", !Ref InfrastructureName]]
        Value: "shared"

  RegisterMaster1:
    Condition: DoRegistration
    Type: Custom::NLBRegister
    Properties:
      ServiceToken: !Ref RegisterNlbIpTargetsLambdaArn
      TargetArn: !Ref ExternalApiTargetGroupArn
      TargetIp: !GetAtt Master1.PrivateIp

  RegisterMaster1InternalApiTarget:
    Condition: DoRegistration
    Type: Custom::NLBRegister
    Properties:
      ServiceToken: !Ref RegisterNlbIpTargetsLambdaArn
      TargetArn: !Ref InternalApiTargetGroupArn
      TargetIp: !GetAtt Master1.PrivateIp

  RegisterMaster1InternalServiceTarget:
    Condition: DoRegistration
    Type: Custom::NLBRegister
    Properties:
      ServiceToken: !Ref RegisterNlbIpTargetsLambdaArn
      TargetArn: !Ref InternalServiceTargetGroupArn
      TargetIp: !GetAtt Master1.PrivateIp

  Master2:
    Type: AWS::EC2::Instance
    Properties:
      ImageId: !Ref RhcosAmi
      BlockDeviceMappings:
      - DeviceName: /dev/xvda
        Ebs:
          VolumeSize: "120"
          VolumeType: "gp2"
      IamInstanceProfile: !Ref MasterInstanceProfileName
```

```
      InstanceType: !Ref MasterInstanceType
      NetworkInterfaces:
      - AssociatePublicIpAddress: "false"
        DeviceIndex: "0"
        GroupSet:
        - !Ref "MasterSecurityGroupId"
        SubnetId: !Ref "Master2Subnet"
      UserData:
        Fn::Base64: !Sub
        - '{"ignition":{"config":{"merge":[{"source":"${SOURCE}"}]},"security":{"tls":
{"certificateAuthorities":[{"source":"${CA_BUNDLE}"}]}},"version":"3.1.0"}}'
        - {
          SOURCE: !Ref IgnitionLocation,
          CA_BUNDLE: !Ref CertificateAuthorities,
        }
      Tags:
      - Key: !Join ["", ["kubernetes.io/cluster/", !Ref InfrastructureName]]
        Value: "shared"

  RegisterMaster2:
    Condition: DoRegistration
    Type: Custom::NLBRegister
    Properties:
      ServiceToken: !Ref RegisterNlbIpTargetsLambdaArn
      TargetArn: !Ref ExternalApiTargetGroupArn
      TargetIp: !GetAtt Master2.PrivateIp

  RegisterMaster2InternalApiTarget:
    Condition: DoRegistration
    Type: Custom::NLBRegister
    Properties:
      ServiceToken: !Ref RegisterNlbIpTargetsLambdaArn
      TargetArn: !Ref InternalApiTargetGroupArn
      TargetIp: !GetAtt Master2.PrivateIp

  RegisterMaster2InternalServiceTarget:
    Condition: DoRegistration
    Type: Custom::NLBRegister
    Properties:
      ServiceToken: !Ref RegisterNlbIpTargetsLambdaArn
      TargetArn: !Ref InternalServiceTargetGroupArn
      TargetIp: !GetAtt Master2.PrivateIp

Outputs:
  PrivateIPs:
    Description: The control-plane node private IP addresses.
    Value:
      !Join [
        ",",
        [!GetAtt Master0.PrivateIp, !GetAtt Master1.PrivateIp, !GetAtt Master2.PrivateIp]
      ]
```

Additional resources

- You can view details about the CloudFormation stacks that you create by navigating to the AWS CloudFormation console.

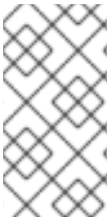
5.13.17. Creating the worker nodes in AWS

You can create worker nodes in Amazon Web Services (AWS) for your cluster to use.

You can use the provided CloudFormation template and a custom parameter file to create a stack of AWS resources that represent a worker node.

IMPORTANT

The CloudFormation template creates a stack that represents one worker node. You must create a stack for each worker node.



NOTE

If you do not use the provided CloudFormation template to create your worker nodes, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

Prerequisites

- You configured an AWS account.
- You added your AWS keys and region to your local AWS profile by running **aws configure**.
- You generated the Ignition config files for your cluster.
- You created and configured a VPC and associated subnets in AWS.
- You created and configured DNS, load balancers, and listeners in AWS.
- You created the security groups and roles required for your cluster in AWS.
- You created the bootstrap machine.
- You created the control plane machines.

Procedure

1. Create a JSON file that contains the parameter values that the CloudFormation template requires:

```
[
  {
    "ParameterKey": "InfrastructureName", 1
    "ParameterValue": "mycluster-<random_string>" 2
  },
  {
    "ParameterKey": "RhcosAmi", 3
    "ParameterValue": "ami-<random_string>" 4
  },
```

```
  {
    "ParameterKey": "Subnet", 5
    "ParameterValue": "subnet-<random_string>" 6
  },
  {
    "ParameterKey": "WorkerSecurityGroupId", 7
    "ParameterValue": "sg-<random_string>" 8
  },
  {
    "ParameterKey": "IgnitionLocation", 9
    "ParameterValue": "https://api-int.<cluster_name>.<domain_name>:22623/config/worker"
10
  },
  {
    "ParameterKey": "CertificateAuthorities", 11
    "ParameterValue": "" 12
  },
  {
    "ParameterKey": "WorkerInstanceProfileName", 13
    "ParameterValue": "" 14
  },
  {
    "ParameterKey": "WorkerInstanceType", 15
    "ParameterValue": "" 16
  }
]
```

1. The name for your cluster infrastructure that is encoded in your Ignition config files for the cluster.
2. Specify the infrastructure name that you extracted from the Ignition config file metadata, which has the format **<cluster-name>-<random-string>**.
3. Current Red Hat Enterprise Linux CoreOS (RHCOS) AMI to use for the worker nodes based on your selected architecture.
4. Specify an **AWS::EC2::Image::Id** value.
5. A subnet, preferably private, to start the worker nodes on.
6. Specify a subnet from the **PrivateSubnets** value from the output of the CloudFormation template for DNS and load balancing.
7. The worker security group ID to associate with worker nodes.
8. Specify the **WorkerSecurityGroupId** value from the output of the CloudFormation template for the security group and roles.
9. The location to fetch the bootstrap Ignition config file from.
10. Specify the generated Ignition config location, **https://api-int.<cluster_name>.<domain_name>:22623/config/worker**.
11. Base64 encoded certificate authority string to use.

12 Specify the value from the **worker.ign** file that is in the installation directory. This value is the long string with the format **data:text/plain;charset=utf-8;base64,ABC...xYz==**.

13 The IAM profile to associate with worker nodes.

14 Specify the **WorkerInstanceProfile** parameter value from the output of the CloudFormation template for the security group and roles.

15 The type of AWS instance to use for the compute machines based on your selected architecture.

16 The instance type value corresponds to the minimum resource requirements for compute machines. For example **m6i.large** is a type for AMD64. and **m6g.large** is a type for ARM64.

2. Copy the template from the **CloudFormation template for worker machines** section of this topic and save it as a YAML file on your computer. This template describes the networking objects and load balancers that your cluster requires.

3. Optional: If you specified an **m5** instance type as the value for **WorkerInstanceType**, add that instance type to the **WorkerInstanceType.AllowedValues** parameter in the CloudFormation template.

4. Optional: If you are deploying with an AWS Marketplace image, update the **Worker0.type.properties.ImageID** parameter with the AMI ID that you obtained from your subscription.

5. Use the CloudFormation template to create a stack of AWS resources that represent a worker node:

IMPORTANT

You must enter the command on a single line.

```
$ aws cloudformation create-stack --stack-name <name> 1
    --template-body file://<template>.yaml \ 2
    --parameters file://<parameters>.json 3
```

1 **<name>** is the name for the CloudFormation stack, such as **cluster-worker-1**. You need the name of this stack if you remove the cluster.

2 **<template>** is the relative path to and name of the CloudFormation template YAML file that you saved.

3 **<parameters>** is the relative path to and name of the CloudFormation parameters JSON file.

Example output

```
arn:aws:cloudformation:us-east-1:269333783861:stack/cluster-worker-1/729ee301-1c2a-11eb-348f-sd9888c65b59
```

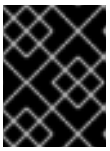
NOTE

The CloudFormation template creates a stack that represents one worker node.

6. Confirm that the template components exist:

```
$ aws cloudformation describe-stacks --stack-name <name>
```

7. Continue to create worker stacks until you have created enough worker machines for your cluster. You can create additional worker stacks by referencing the same template and parameter files and specifying a different stack name.



IMPORTANT

You must create at least two worker machines, so you must create at least two stacks that use this CloudFormation template.

5.13.17.1. CloudFormation template for worker machines

You can use the following CloudFormation template to deploy the worker machines that you need for your OpenShift Container Platform cluster.

Example 5.49. CloudFormation template for worker machines

```
AWSTemplateFormatVersion: 2010-09-09
Description: Template for OpenShift Cluster Node Launch (EC2 worker instance)

Parameters:
  InfrastructureName:
    AllowedPattern: ^([a-zA-Z][a-zA-Z0-9\-]{0,26})$
    MaxLength: 27
    MinLength: 1
    ConstraintDescription: Infrastructure name must be alphanumeric, start with a letter, and have a
maximum of 27 characters.
    Description: A short, unique cluster ID used to tag nodes for the kubelet cloud provider.
    Type: String
  RhcosAmi:
    Description: Current Red Hat Enterprise Linux CoreOS AMI to use for bootstrap.
    Type: AWS::EC2::Image::Id
  Subnet:
    Description: The subnets, recommend private, to launch the master nodes into.
    Type: AWS::EC2::Subnet::Id
  WorkerSecurityGroupId:
    Description: The master security group ID to associate with master nodes.
    Type: AWS::EC2::SecurityGroup::Id
  IgnitionLocation:
    Default: https://api-int.$CLUSTER_NAME.$DOMAIN:22623/config/worker
    Description: Ignition config file location.
    Type: String
  CertificateAuthorities:
    Default: data:text/plain;charset=utf-8;base64,ABC...xYz==
    Description: Base64 encoded certificate authority string to use.
    Type: String
  WorkerInstanceProfileName:
```

```
    Description: IAM profile to associate with master nodes.
    Type: String
  WorkerInstanceType:
    Default: m5.large
    Type: String

Metadata:
  AWS::CloudFormation::Interface:
    ParameterGroups:
    - Label:
        default: "Cluster Information"
      Parameters:
      - InfrastructureName
    - Label:
        default: "Host Information"
      Parameters:
      - WorkerInstanceType
      - RhcosAmi
      - IgnitionLocation
      - CertificateAuthorities
      - WorkerSecurityGroupId
      - WorkerInstanceProfileName
    - Label:
        default: "Network Configuration"
      Parameters:
      - Subnet
    ParameterLabels:
      Subnet:
        default: "Subnet"
      InfrastructureName:
        default: "Infrastructure Name"
      WorkerInstanceType:
        default: "Worker Instance Type"
      WorkerInstanceProfileName:
        default: "Worker Instance Profile Name"
      RhcosAmi:
        default: "Red Hat Enterprise Linux CoreOS AMI ID"
      IgnitionLocation:
        default: "Worker Ignition Source"
      CertificateAuthorities:
        default: "Ignition CA String"
      WorkerSecurityGroupId:
        default: "Worker Security Group ID"

Resources:
  Worker0:
    Type: AWS::EC2::Instance
    Properties:
      ImageId: !Ref RhcosAmi
      BlockDeviceMappings:
      - DeviceName: /dev/xvda
        Ebs:
          VolumeSize: "120"
          VolumeType: "gp2"
      IamInstanceProfile: !Ref WorkerInstanceProfileName
      InstanceType: !Ref WorkerInstanceType
```

```
      NetworkInterfaces:
      - AssociatePublicIpAddress: "false"
        DeviceIndex: "0"
        GroupSet:
        - !Ref "WorkerSecurityGroupId"
        SubnetId: !Ref "Subnet"
      UserData:
        Fn::Base64: !Sub
        - '{"ignition":{"config":{"merge":[{"source":"${SOURCE}"}]},"security":{"tls":
{"certificateAuthorities":[{"source":"${CA_BUNDLE}"}]}},"version":"3.1.0"}}'
        - {
          SOURCE: !Ref IgnitionLocation,
          CA_BUNDLE: !Ref CertificateAuthorities,
        }
      Tags:
      - Key: !Join ["", ["kubernetes.io/cluster/", !Ref InfrastructureName]]
        Value: "shared"

Outputs:
  PrivateIP:
    Description: The compute node private IP address.
    Value: !GetAtt Worker0.PrivateIp
```

Additional resources

- You can view details about the CloudFormation stacks that you create by navigating to the AWS CloudFormation console.

5.13.18. Initializing the bootstrap sequence on AWS with user-provisioned infrastructure

After you create all of the required infrastructure in Amazon Web Services (AWS), you can start the bootstrap sequence that initializes the OpenShift Container Platform control plane.

Prerequisites

- You configured an AWS account.
- You added your AWS keys and region to your local AWS profile by running **aws configure**.
- You generated the Ignition config files for your cluster.
- You created and configured a VPC and associated subnets in AWS.
- You created and configured DNS, load balancers, and listeners in AWS.
- You created the security groups and roles required for your cluster in AWS.
- You created the bootstrap machine.
- You created the control plane machines.
- You created the worker nodes.

Procedure

1. Change to the directory that contains the installation program and start the bootstrap process that initializes the OpenShift Container Platform control plane:

```
$ ./openshift-install wait-for bootstrap-complete --dir <installation_directory> \ 1
    --log-level=info 2
```

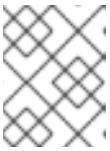
1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

Example output

```
INFO Waiting up to 20m0s for the Kubernetes API at
https://api.mycluster.example.com:6443...
INFO API v1.24.0 up
INFO Waiting up to 30m0s for bootstrapping to complete...
INFO It is now safe to remove the bootstrap resources
INFO Time elapsed: 1s
```

If the command exits without a **FATAL** warning, your OpenShift Container Platform control plane has initialized.



NOTE

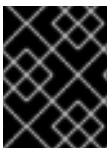
After the control plane initializes, it sets up the compute nodes and installs additional services in the form of Operators.

Additional resources

- See Monitoring installation progress for details about monitoring the installation, bootstrap, and control plane logs as an OpenShift Container Platform installation progresses.
- See Gathering bootstrap node diagnostic data for information about troubleshooting issues related to the bootstrap process.
- You can view details about the running instances that are created by using the AWS EC2 console.

5.13.19. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.



IMPORTANT

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.11. Download and install the new version of **oc**.

Installing the OpenShift CLI on Linux

You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the architecture in the **Product Variant** drop-down menu.
3. Select the appropriate version in the **Version** drop-down menu.
4. Click **Download Now** next to the **OpenShift v4.11 Linux Client** entry and save the file.
5. Unpack the archive:

```
$ tar xvf <file>
```

6. Place the **oc** binary in a directory that is on your **PATH**.
   To check your **PATH**, execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.
   To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
C:\> oc <command>
```

Installing the OpenShift CLI on macOS

You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 macOS Client** entry and save the file.

NOTE

For macOS arm64, choose the **OpenShift v4.11 macOS arm64 Client** entry.

4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your PATH.
   To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

5.13.20. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

Example output

```
system:admin
```

5.13.21. Approving the certificate signing requests for your machines

When you add machines to a cluster, two pending certificate signing requests (CSRs) are generated for each machine that you added. You must confirm that these CSRs are approved or, if necessary, approve them yourself. The client requests must be approved first, followed by the server requests.

Prerequisites

- You added machines to your cluster.

Procedure

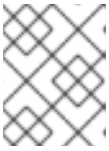
1. Confirm that the cluster recognizes the machines:

```
$ oc get nodes
```

Example output

```
NAME      STATUS    ROLES   AGE  VERSION
master-0  Ready     master  63m  v1.24.0
master-1  Ready     master  63m  v1.24.0
master-2  Ready     master  64m  v1.24.0
```

The output lists all of the machines that you created.



NOTE

The preceding output might not include the compute nodes, also known as worker nodes, until some CSRs are approved.

2. Review the pending CSRs and ensure that you see the client requests with the **Pending** or **Approved** status for each machine that you added to the cluster:

```
$ oc get csr
```

Example output

```
NAME        AGE     REQUESTOR                                                   CONDITION
csr-8b2br   15m     system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper   Pending
csr-8vnps   15m     system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper   Pending
...
```

In this example, two machines are joining the cluster. You might see more approved CSRs in the list.

3. If the CSRs were not approved, after all of the pending CSRs for the machines you added are in **Pending** status, approve the CSRs for your cluster machines:

NOTE

Because the CSRs rotate automatically, approve your CSRs within an hour of adding the machines to the cluster. If you do not approve them within an hour, the certificates will rotate, and more than two certificates will be present for each node. You must approve all of these certificates. After the client CSR is approved, the Kubelet creates a secondary CSR for the serving certificate, which requires manual approval. Then, subsequent serving certificate renewal requests are automatically approved by the **machine-approver** if the Kubelet requests a new certificate with identical parameters.

NOTE

For clusters running on platforms that are not machine API enabled, such as bare metal and other user-provisioned infrastructure, you must implement a method of automatically approving the kubelet serving certificate requests (CSRs). If a request is not approved, then the **oc exec**, **oc rsh**, and **oc logs** commands cannot succeed, because a serving certificate is required when the API server connects to the kubelet. Any operation that contacts the Kubelet endpoint requires this certificate approval to be in place. The method must watch for new CSRs, confirm that the CSR was submitted by the **node-bootstrapper** service account in the **system:node** or **system:admin** groups, and confirm the identity of the node.

- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

1 **<csr_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{{"\n"}}
{{end}}{{end}}' | xargs --no-run-if-empty oc adm certificate approve
```

NOTE

Some Operators might not become available until some CSRs are approved.

4. Now that your client requests are approved, you must review the server requests for each machine that you added to the cluster:

```
$ oc get csr
```

Example output

```
NAME        AGE    REQUESTOR                                                   CONDITION
csr-bfd72   5m26s  system:node:ip-10-0-50-126.us-east-2.compute.internal
Pending
```

```
csr-c57lv   5m26s   system:node:ip-10-0-95-157.us-east-2.compute.internal
Pending
...
```

5. If the remaining CSRs are not approved, and are in the **Pending** status, approve the CSRs for your cluster machines:

   - To approve them individually, run the following command for each valid CSR:

     ```
     $ oc adm certificate approve <csr_name> 1
     ```

     1 **<csr_name>** is the name of a CSR from the list of current CSRs.

   - To approve all pending CSRs, run the following command:

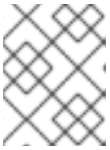
     ```
     $ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{{"\n"}}
     {{end}}{{end}}' | xargs oc adm certificate approve
     ```

6. After all client and server CSRs have been approved, the machines have the **Ready** status. Verify this by running the following command:

   ```
   $ oc get nodes
   ```

   Example output

   ```
   NAME      STATUS    ROLES   AGE  VERSION
   master-0  Ready     master  73m  v1.24.0
   master-1  Ready     master  73m  v1.24.0
   master-2  Ready     master  74m  v1.24.0
   worker-0  Ready     worker  11m  v1.24.0
   worker-1  Ready     worker  11m  v1.24.0
   ```



NOTE

It can take a few minutes after approval of the server CSRs for the machines to transition to the **Ready** status.

Additional information

- For more information on CSRs, see Certificate Signing Requests.

5.13.22. Initial Operator configuration

After the control plane initializes, you must immediately configure some Operators so that they all become available.

Prerequisites

- Your control plane has initialized.

Procedure

1. Watch the cluster components come online:

```
$ watch -n5 oc get clusteroperators
```

Example output

```
NAME                                       VERSION   AVAILABLE   PROGRESSING   DEGRADED
SINCE
authentication                             4.11.0    True        False         False      19m
baremetal                                  4.11.0    True        False         False      37m
cloud-credential                           4.11.0    True        False         False      40m
cluster-autoscaler                         4.11.0    True        False         False      37m
config-operator                            4.11.0    True        False         False      38m
console                                    4.11.0    True        False         False      26m
csi-snapshot-controller                    4.11.0    True        False         False      37m
dns                                        4.11.0    True        False         False      37m
etcd                                       4.11.0    True        False         False      36m
image-registry                             4.11.0    True        False         False      31m
ingress                                    4.11.0    True        False         False      30m
insights                                   4.11.0    True        False         False      31m
kube-apiserver                             4.11.0    True        False         False      26m
kube-controller-manager                    4.11.0    True        False         False      36m
kube-scheduler                             4.11.0    True        False         False      36m
kube-storage-version-migrator              4.11.0    True        False         False      37m
machine-api                                4.11.0    True        False         False      29m
machine-approver                           4.11.0    True        False         False      37m
machine-config                             4.11.0    True        False         False      36m
marketplace                                4.11.0    True        False         False      37m
monitoring                                 4.11.0    True        False         False      29m
network                                    4.11.0    True        False         False      38m
node-tuning                                4.11.0    True        False         False      37m
openshift-apiserver                        4.11.0    True        False         False      32m
openshift-controller-manager               4.11.0    True        False         False      30m
openshift-samples                          4.11.0    True        False         False      32m
operator-lifecycle-manager                 4.11.0    True        False         False      37m
operator-lifecycle-manager-catalog         4.11.0    True        False         False      37m
operator-lifecycle-manager-packageserver   4.11.0    True        False         False      32m
service-ca                                 4.11.0    True        False         False      38m
storage                                    4.11.0    True        False         False      37m
```

2. Configure the Operators that are not available.

5.13.22.1. Image registry storage configuration

Amazon Web Services provides default storage, which means the Image Registry Operator is available after installation. However, if the Registry Operator cannot create an S3 bucket and automatically configure storage, you must manually configure registry storage.

Instructions are shown for configuring a persistent volume, which is required for production clusters. Where applicable, instructions are shown for configuring an empty directory as the storage location, which is available for only non-production clusters.

Additional instructions are provided for allowing the image registry to use block storage types by using the **Recreate** rollout strategy during upgrades.

You can configure registry storage for user-provisioned infrastructure in AWS to deploy OpenShift Container Platform to hidden regions. See Configuring the registry for AWS user-provisioned infrastructure for more information.

5.13.22.1.1. Configuring registry storage for AWS with user-provisioned infrastructure

During installation, your cloud credentials are sufficient to create an Amazon S3 bucket and the Registry Operator will automatically configure storage.

If the Registry Operator cannot create an S3 bucket and automatically configure storage, you can create an S3 bucket and configure storage with the following procedure.

Prerequisites

- You have a cluster on AWS with user-provisioned infrastructure.
- For Amazon S3 storage, the secret is expected to contain two keys:
  - **REGISTRY_STORAGE_S3_ACCESSKEY**
  - **REGISTRY_STORAGE_S3_SECRETKEY**

Procedure

Use the following procedure if the Registry Operator cannot create an S3 bucket and automatically configure storage.

1. Set up a Bucket Lifecycle Policy to abort incomplete multipart uploads that are one day old.
2. Fill in the storage configuration in **configs.imageregistry.operator.openshift.io/cluster**:

```
$ oc edit configs.imageregistry.operator.openshift.io/cluster
```

Example configuration

```
storage:
  s3:
    bucket: <bucket-name>
    region: <region-name>
```

WARNING

To secure your registry images in AWS, block public access to the S3 bucket.

5.13.22.1.2. Configuring storage for the image registry in non-production clusters

You must configure storage for the Image Registry Operator. For non-production clusters, you can set the image registry to an empty directory. If you do so, all images are lost if you restart the registry.

Procedure

- To set the image registry storage to an empty directory:

```
$ oc patch configs.imageregistry.operator.openshift.io cluster --type merge --patch '{"spec":{"storage":{"emptyDir":{}}}}'
```

WARNING

Configure this option for only non-production clusters.

If you run this command before the Image Registry Operator initializes its components, the **oc patch** command fails with the following error:

```
Error from server (NotFound): configs.imageregistry.operator.openshift.io "cluster" not found
```

Wait a few minutes and run the command again.

5.13.23. Deleting the bootstrap resources

After you complete the initial Operator configuration for the cluster, remove the bootstrap resources from Amazon Web Services (AWS).

Prerequisites

- You completed the initial Operator configuration for your cluster.

Procedure

1. Delete the bootstrap resources. If you used the CloudFormation template, delete its stack:
   - Delete the stack by using the AWS CLI:

```
$ aws cloudformation delete-stack --stack-name <name> 1
```

1 **<name>** is the name of your bootstrap stack.

   - Delete the stack by using the AWS CloudFormation console.

5.13.24. Creating the Ingress DNS Records

If you removed the DNS Zone configuration, manually create DNS records that point to the Ingress load balancer. You can create either a wildcard record or specific records. While the following procedure uses A records, you can use other record types that you require, such as CNAME or alias.

Prerequisites

- You deployed an OpenShift Container Platform cluster on Amazon Web Services (AWS) that uses infrastructure that you provisioned.

- You installed the OpenShift CLI (**oc**).
- You installed the **jq** package.
- You downloaded the AWS CLI and installed it on your computer. See Install the AWS CLI Using the Bundled Installer (Linux, macOS, or Unix).

Procedure

1. Determine the routes to create.
   - To create a wildcard record, use ***.apps.<cluster_name>.<domain_name>**, where **<cluster_name>** is your cluster name, and **<domain_name>** is the Route 53 base domain for your OpenShift Container Platform cluster.
   - To create specific records, you must create a record for each route that your cluster uses, as shown in the output of the following command:

     ```
     $ oc get --all-namespaces -o jsonpath='{range .items[*]}{range .status.ingress[*]}{.host}
     {"\n"}{end}{end}' routes
     ```

     Example output

     ```
     oauth-openshift.apps.<cluster_name>.<domain_name>
     console-openshift-console.apps.<cluster_name>.<domain_name>
     downloads-openshift-console.apps.<cluster_name>.<domain_name>
     alertmanager-main-openshift-monitoring.apps.<cluster_name>.<domain_name>
     prometheus-k8s-openshift-monitoring.apps.<cluster_name>.<domain_name>
     ```

2. Retrieve the Ingress Operator load balancer status and note the value of the external IP address that it uses, which is shown in the **EXTERNAL-IP** column:

   ```
   $ oc -n openshift-ingress get service router-default
   ```

   Example output

   ```
   NAME              TYPE           CLUSTER-IP      EXTERNAL-IP                            PORT(S)
   AGE
   router-default    LoadBalancer   172.30.62.215   ab3...28.us-east-2.elb.amazonaws.com
   80:31499/TCP,443:30693/TCP   5m
   ```

3. Locate the hosted zone ID for the load balancer:

   ```
   $ aws elb describe-load-balancers | jq -r '.LoadBalancerDescriptions[] | select(.DNSName ==
   "<external_ip>").CanonicalHostedZoneNameID' 1
   ```

   1 For **<external_ip>**, specify the value of the external IP address of the Ingress Operator load balancer that you obtained.

   Example output

   ```
   Z3AADJGX6KTTL2
   ```

The output of this command is the load balancer hosted zone ID.

4. Obtain the public hosted zone ID for your cluster's domain:

```
$ aws route53 list-hosted-zones-by-name \
        --dns-name "<domain_name>" \ 1
        --query 'HostedZones[? Config.PrivateZone != `true` && Name ==
`<domain_name>.`].Id' 2
        --output text
```

1 2 For **<domain_name>**, specify the Route 53 base domain for your OpenShift Container Platform cluster.

Example output

```
/hostedzone/Z3URY6TWQ91KVV
```

The public hosted zone ID for your domain is shown in the command output. In this example, it is **Z3URY6TWQ91KVV**.

5. Add the alias records to your private zone:

```
$ aws route53 change-resource-record-sets --hosted-zone-id "<private_hosted_zone_id>" --
change-batch '{ 1
>   "Changes": [
>     {
>       "Action": "CREATE",
>       "ResourceRecordSet": {
>         "Name": "\\052.apps.<cluster_domain>", 2
>         "Type": "A",
>         "AliasTarget":{
>           "HostedZoneId": "<hosted_zone_id>", 3
>           "DNSName": "<external_ip>.", 4
>           "EvaluateTargetHealth": false
>         }
>       }
>     }
>   ]
> }'
```

1 For **<private_hosted_zone_id>**, specify the value from the output of the CloudFormation template for DNS and load balancing.

2 For **<cluster_domain>**, specify the domain or subdomain that you use with your OpenShift Container Platform cluster.

3 For **<hosted_zone_id>**, specify the public hosted zone ID for the load balancer that you obtained.

4 For **<external_ip>**, specify the value of the external IP address of the Ingress Operator load balancer. Ensure that you include the trailing period (**.**) in this parameter value.

6. Add the records to your public zone:

```
$ aws route53 change-resource-record-sets --hosted-zone-id "<public_hosted_zone_id>"" --
change-batch '{ 1
>   "Changes": [
>     {
>       "Action": "CREATE",
>       "ResourceRecordSet": {
>         "Name": "\\052.apps.<cluster_domain>", 2
>         "Type": "A",
>         "AliasTarget":{
>           "HostedZoneId": "<hosted_zone_id>", 3
>           "DNSName": "<external_ip>.", 4
>           "EvaluateTargetHealth": false
>         }
>       }
>     }
>   ]
> }'
```

1. For **<public_hosted_zone_id>**, specify the public hosted zone for your domain.
2. For **<cluster_domain>**, specify the domain or subdomain that you use with your OpenShift Container Platform cluster.
3. For **<hosted_zone_id>**, specify the public hosted zone ID for the load balancer that you obtained.
4. For **<external_ip>**, specify the value of the external IP address of the Ingress Operator load balancer. Ensure that you include the trailing period (**.**) in this parameter value.

5.13.25. Completing an AWS installation on user-provisioned infrastructure

After you start the OpenShift Container Platform installation on Amazon Web Service (AWS) user-provisioned infrastructure, monitor the deployment to completion.

Prerequisites

- You removed the bootstrap node for an OpenShift Container Platform cluster on user-provisioned AWS infrastructure.
- You installed the **oc** CLI.

Procedure

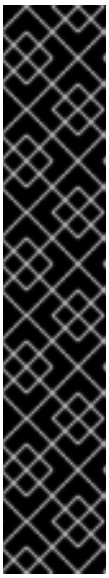
- From the directory that contains the installation program, complete the cluster installation:

```
$ ./openshift-install --dir <installation_directory> wait-for install-complete 1
```

1. For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

Example output

```
INFO Waiting up to 40m0s for the cluster at https://api.mycluster.example.com:6443 to
initialize...
INFO Waiting up to 10m0s for the openshift-console route to be created...
INFO Install complete!
INFO To access the cluster as the system:admin user when using 'oc', run 'export
KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
INFO Access the OpenShift web-console here: https://console-openshift-
console.apps.mycluster.example.com
INFO Login to the console with user: "kubeadmin", and password: "password"
INFO Time elapsed: 1s
```



IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

5.13.26. Logging in to the cluster by using the web console

The **kubeadmin** user exists by default after an OpenShift Container Platform installation. You can log in to your cluster as the **kubeadmin** user by using the OpenShift Container Platform web console.

Prerequisites

- You have access to the installation host.
- You completed a cluster installation and all cluster Operators are available.

Procedure

1. Obtain the password for the **kubeadmin** user from the **kubeadmin-password** file on the installation host:

```
$ cat <installation_directory>/auth/kubeadmin-password
```

NOTE

Alternatively, you can obtain the **kubeadmin** password from the **<installation_directory>/.openshift_install.log** log file on the installation host.

2. List the OpenShift Container Platform web console route:

```
$ oc get routes -n openshift-console | grep 'console-openshift'
```

NOTE

Alternatively, you can obtain the OpenShift Container Platform route from the **<installation_directory>/.openshift_install.log** log file on the installation host.

Example output

```
console     console-openshift-console.apps.<cluster_name>.<base_domain>          console
https   reencrypt/Redirect   None
```

3. Navigate to the route detailed in the output of the preceding command in a web browser and log in as the **kubeadmin** user.

Additional resources

- See Accessing the web console for more details about accessing and understanding the OpenShift Container Platform web console.

5.13.27. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.11, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to OpenShift Cluster Manager Hybrid Cloud Console.

After you confirm that your OpenShift Cluster Manager Hybrid Cloud Console inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, use subscription watch to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

Additional resources

- See About remote health monitoring for more information about the Telemetry service.

5.13.28. Additional resources

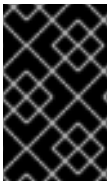
- See Working with stacks in the AWS documentation for more information about AWS CloudFormation stacks.

5.13.29. Next steps

- Validating an installation.
- Customize your cluster.
- If necessary, you can opt out of remote health reporting .
- If necessary, you can remove cloud provider credentials.

5.14. INSTALLING A CLUSTER ON AWS IN A RESTRICTED NETWORK WITH USER-PROVISIONED INFRASTRUCTURE

In OpenShift Container Platform version 4.11, you can install a cluster on Amazon Web Services (AWS) using infrastructure that you provide and an internal mirror of the installation release content.



IMPORTANT

While you can install an OpenShift Container Platform cluster by using mirrored installation release content, your cluster still requires internet access to use the AWS APIs.

One way to create this infrastructure is to use the provided CloudFormation templates. You can modify the templates to customize your infrastructure or use the information that they contain to create AWS objects according to your company's policies.

IMPORTANT

The steps for performing a user-provisioned infrastructure installation are provided as an example only. Installing a cluster with infrastructure you provide requires knowledge of the cloud provider and the installation process of OpenShift Container Platform. Several CloudFormation templates are provided to assist in completing these steps or to help model your own. You are also free to create the required resources through other methods; the templates are just an example.

5.14.1. Prerequisites

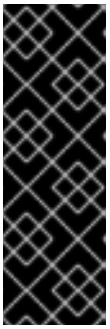
- You reviewed details about the OpenShift Container Platform installation and update processes.
- You read the documentation on selecting a cluster installation method and preparing it for users.
- You created a mirror registry on your mirror host and obtained the **imageContentSources** data for your version of OpenShift Container Platform.

  IMPORTANT

  Because the installation media is on the mirror host, you can use that computer to complete all installation steps.

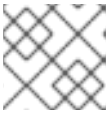
- You configured an AWS account to host the cluster.

  IMPORTANT

  If you have an AWS profile stored on your computer, it must not use a temporary session token that you generated while using a multi-factor authentication device. The cluster continues to use your current AWS credentials to create AWS resources for the entire life of the cluster, so you must use key-based, long-lived credentials. To generate appropriate keys, see Managing Access Keys for IAM Users in the AWS documentation. You can supply the keys when you run the installation program.

- You downloaded the AWS CLI and installed it on your computer. See Install the AWS CLI Using the Bundled Installer (Linux, macOS, or Unix) in the AWS documentation.
- If you use a firewall and plan to use the Telemetry service, you configured the firewall to allow the sites that your cluster requires access to.



NOTE

Be sure to also review this site list if you are configuring a proxy.

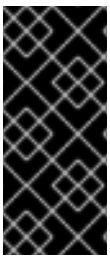
- If the cloud identity and access management (IAM) APIs are not accessible in your environment, or if you do not want to store an administrator-level credential secret in the **kube-system** namespace, you can manually create and maintain IAM credentials.

5.14.2. About installations in restricted networks

In OpenShift Container Platform 4.11, you can perform an installation that does not require an active connection to the internet to obtain software components. Restricted network installations can be completed using installer-provisioned infrastructure or user-provisioned infrastructure, depending on the cloud platform to which you are installing the cluster.

If you choose to perform a restricted network installation on a cloud platform, you still require access to its cloud APIs. Some cloud functions, like Amazon Web Service's Route 53 DNS and IAM services, require internet access. Depending on your network, you might require less internet access for an installation on bare metal hardware or on VMware vSphere.

To complete a restricted network installation, you must create a registry that mirrors the contents of the OpenShift image registry and contains the installation media. You can create this registry on a mirror host, which can access both the internet and your closed network, or by using other methods that meet your restrictions.



IMPORTANT

Because of the complexity of the configuration for user-provisioned installations, consider completing a standard user-provisioned infrastructure installation before you attempt a restricted network installation using user-provisioned infrastructure. Completing this test installation might make it easier to isolate and troubleshoot any issues that might arise during your installation in a restricted network.

5.14.2.1. Additional limits

Clusters in restricted networks have the following additional limitations and restrictions:

- The **ClusterVersion** status includes an **Unable to retrieve available updates** error.
- By default, you cannot use the contents of the Developer Catalog because you cannot access the required image stream tags.

5.14.3. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.11, you require access to the internet to obtain the images that are necessary to install your cluster.

You must have internet access to:

- Access OpenShift Cluster Manager Hybrid Cloud Console to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access Quay.io to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.

IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

5.14.4. Requirements for a cluster with user-provisioned infrastructure

For a cluster that contains user-provisioned infrastructure, you must deploy all of the required machines.

This section describes the requirements for deploying OpenShift Container Platform on user-provisioned infrastructure.

5.14.4.1. Required machines for cluster installation

The smallest OpenShift Container Platform clusters require the following hosts:

Table 5.50. Minimum required hosts

Hosts	Description
One temporary bootstrap machine	The cluster requires the bootstrap machine to deploy the OpenShift Container Platform cluster on the three control plane machines. You can remove the bootstrap machine after you install the cluster.
Three control plane machines	The control plane machines run the Kubernetes and OpenShift Container Platform services that form the control plane.
At least two compute machines, which are also known as worker machines.	The workloads requested by OpenShift Container Platform users run on the compute machines.

IMPORTANT

To maintain high availability of your cluster, use separate physical hosts for these cluster machines.

The bootstrap and control plane machines must use Red Hat Enterprise Linux CoreOS (RHCOS) as the operating system. However, the compute machines can choose between Red Hat Enterprise Linux CoreOS (RHCOS), Red Hat Enterprise Linux (RHEL) 8.6 and later.

Note that RHCOS is based on Red Hat Enterprise Linux (RHEL) 8 and inherits all of its hardware certifications and requirements. See Red Hat Enterprise Linux technology capabilities and limits .

Additional resources

- Optimizing storage

5.14.4.2. Minimum resource requirements for cluster installation

Each cluster machine must meet the following minimum requirements:

Table 5.51. Minimum resource requirements

Machine	Operating System	vCPU [1]	Virtual RAM	Storage	IOPS [2]
Bootstrap	RHCOS	4	16 GB	100 GB	300
Control plane	RHCOS	4	16 GB	100 GB	300
Compute	RHCOS, RHEL 8.6 and later [3]	2	8 GB	100 GB	300

1. One vCPU is equivalent to one physical core when simultaneous multithreading (SMT), or hyperthreading, is not enabled. When enabled, use the following formula to calculate the corresponding ratio: (threads per core × cores) × sockets = vCPUs.

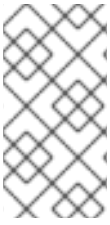
2. OpenShift Container Platform and Kubernetes are sensitive to disk performance, and faster storage is recommended, particularly for etcd on the control plane nodes which require a 10 ms p99 fsync duration. Note that on many cloud platforms, storage size and IOPS scale together, so you might need to over-allocate storage volume to obtain sufficient performance.

3. As with all user-provisioned installations, if you choose to use RHEL compute machines in your cluster, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks. Use of RHEL 7 compute machines is deprecated and has been removed in OpenShift Container Platform 4.10 and later.

If an instance type for your platform meets the minimum requirements for cluster machines, it is supported to use in OpenShift Container Platform.

5.14.4.3. Tested instance types for AWS

The following Amazon Web Services (AWS) instance types have been tested with OpenShift Container Platform.



NOTE

Use the machine types included in the following charts for your AWS instances. If you use an instance type that is not listed in the chart, ensure that the instance size you use matches the minimum resource requirements that are listed in "Minimum resource requirements for cluster installation".

Example 5.50. Machine types based on 64-bit x86 architecture

- **c4.***
- **c5.***
- **c5a.***
- **i3.***
- **m4.***
- **m5.***
- **m5a.***
- **m6a.***
- **m6i.***
- **r4.***
- **r5.***
- **r5a.***
- **r6i.***
- **t3.***
- **t3a.***

5.14.4.4. Tested instance types for AWS on 64-bit ARM infrastructures

The following Amazon Web Services (AWS) ARM64 instance types have been tested with OpenShift Container Platform.

NOTE

Use the machine types included in the following charts for your AWS ARM instances. If you use an instance type that is not listed in the chart, ensure that the instance size you use matches the minimum resource requirements that are listed in "Minimum resource requirements for cluster installation".

Example 5.51. Machine types based on 64-bit ARM architecture

- **c6g.***
- **m6g.***

5.14.4.5. Certificate signing requests management

Because your cluster has limited access to automatic machine management when you use infrastructure

that you provision, you must provide a mechanism for approving cluster certificate signing requests (CSRs) after installation. The **kube-controller-manager** only approves the kubelet client CSRs. The **machine-approver** cannot guarantee the validity of a serving certificate that is requested by using kubelet credentials because it cannot confirm that the correct machine issued the request. You must determine and implement a method of verifying the validity of the kubelet serving certificate requests and approving them.

5.14.5. Required AWS infrastructure components

To install OpenShift Container Platform on user-provisioned infrastructure in Amazon Web Services (AWS), you must manually create both the machines and their supporting infrastructure.

For more information about the integration testing for different platforms, see the OpenShift Container Platform 4.x Tested Integrations page.

By using the provided CloudFormation templates, you can create stacks of AWS resources that represent the following components:

- An AWS Virtual Private Cloud (VPC)
- Networking and load balancing components
- Security groups and roles
- An OpenShift Container Platform bootstrap node
- OpenShift Container Platform control plane nodes
- An OpenShift Container Platform compute node

Alternatively, you can manually create the components or you can reuse existing infrastructure that meets the cluster requirements. Review the CloudFormation templates for more details about how the components interrelate.

5.14.5.1. Other infrastructure components

- A VPC
- DNS entries
- Load balancers (classic or network) and listeners
- A public and a private Route 53 zone
- Security groups
- IAM roles
- S3 buckets

If you are working in a disconnected environment, you are unable to reach the public IP addresses for EC2, ELB, and S3 endpoints. Depending on the level to which you want to restrict internet traffic during the installation, the following configuration options are available:

Option 1: Create VPC endpoints
Create a VPC endpoint and attach it to the subnets that the clusters are using. Name the endpoints as follows:

- **ec2.<region>.amazonaws.com**
- **elasticloadbalancing.<region>.amazonaws.com**
- **s3.<region>.amazonaws.com**

With this option, network traffic remains private between your VPC and the required AWS services.

Option 2: Create a proxy without VPC endpoints
As part of the installation process, you can configure an HTTP or HTTPS proxy. With this option, internet traffic goes through the proxy to reach the required AWS services.

Option 3: Create a proxy with VPC endpoints
As part of the installation process, you can configure an HTTP or HTTPS proxy with VPC endpoints. Create a VPC endpoint and attach it to the subnets that the clusters are using. Name the endpoints as follows:

- **ec2.<region>.amazonaws.com**
- **elasticloadbalancing.<region>.amazonaws.com**
- **s3.<region>.amazonaws.com**

When configuring the proxy in the **install-config.yaml** file, add these endpoints to the **noProxy** field. With this option, the proxy prevents the cluster from accessing the internet directly. However, network traffic remains private between your VPC and the required AWS services.

Required VPC components

You must provide a suitable VPC and subnets that allow communication to your machines.

Component	AWS type	Description
VPC	• **AWS::EC2::VPC** • **AWS::EC2::VPCEndpoint**	You must provide a public VPC for the cluster to use. The VPC uses an endpoint that references the route tables for each subnet to improve communication with the registry that is hosted in S3.
Public subnets	• **AWS::EC2::Subnet** • **AWS::EC2::SubnetNetworkAclAssociation**	Your VPC must have public subnets for between 1 and 3 availability zones and associate them with appropriate Ingress rules.

<table>
<tr><th>Component</th><th>AWS type</th><th>Description</th></tr>
<tr><td>Internet gateway</td><td>AWS::EC2::InternetGateway
AWS::EC2::VPCGatewayAttachment
AWS::EC2::RouteTable
AWS::EC2::Route
AWS::EC2::SubnetRouteTableAssociation
AWS::EC2::NatGateway
AWS::EC2::EIP</td><td>You must have a public internet gateway, with public routes, attached to the VPC. In the provided templates, each public subnet has a NAT gateway with an EIP address. These NAT gateways allow cluster resources, like private subnet instances, to reach the internet and are not required for some restricted network or proxy scenarios.</td></tr>
<tr><td>Network access control</td><td>AWS::EC2::NetworkAcl
AWS::EC2::NetworkAclEntry</td><td>You must allow the VPC to access the following ports:<table><tr><th>Port</th><th>Reason</th></tr><tr><td>80</td><td>Inbound HTTP traffic</td></tr><tr><td>443</td><td>Inbound HTTPS traffic</td></tr><tr><td>22</td><td>Inbound SSH traffic</td></tr><tr><td>1024 - 65535</td><td>Inbound ephemeral traffic</td></tr><tr><td>0 - 65535</td><td>Outbound ephemeral traffic</td></tr></table></td></tr>
<tr><td>Private subnets</td><td>AWS::EC2::Subnet
AWS::EC2::RouteTable
AWS::EC2::SubnetRouteTableAssociation</td><td>Your VPC can have private subnets. The provided CloudFormation templates can create private subnets for between 1 and 3 availability zones. If you use private subnets, you must provide appropriate routes and tables for them.</td></tr>
</table>

Required DNS and load balancing components

Your DNS and load balancer configuration needs to use a public hosted zone and can use a private hosted zone similar to the one that the installation program uses if it provisions the cluster's

infrastructure. You must create a DNS entry that resolves to your load balancer. An entry for **api.<cluster_name>.<domain>** must point to the external load balancer, and an entry for **api-int.<cluster_name>.<domain>** must point to the internal load balancer.

The cluster also requires load balancers and listeners for port 6443, which are required for the Kubernetes API and its extensions, and port 22623, which are required for the Ignition config files for new machines. The targets will be the control plane nodes. Port 6443 must be accessible to both clients external to the cluster and nodes within the cluster. Port 22623 must be accessible to nodes within the cluster.

Component	AWS type	Description
DNS	**AWS::Route53::HostedZone**	The hosted zone for your internal DNS.
Public load balancer	**AWS::ElasticLoadBalancingV2::LoadBalancer**	The load balancer for your public subnets.
External API server record	**AWS::Route53::RecordSetGroup**	Alias records for the external API server.
External listener	**AWS::ElasticLoadBalancingV2::Listener**	A listener on port 6443 for the external load balancer.
External target group	**AWS::ElasticLoadBalancingV2::TargetGroup**	The target group for the external load balancer.
Private load balancer	**AWS::ElasticLoadBalancingV2::LoadBalancer**	The load balancer for your private subnets.
Internal API server record	**AWS::Route53::RecordSetGroup**	Alias records for the internal API server.
Internal listener	**AWS::ElasticLoadBalancingV2::Listener**	A listener on port 22623 for the internal load balancer.

Component	AWS type	Description
Internal target group	**AWS::ElasticLoadBalancingV2::TargetGroup**	The target group for the internal load balancer.
Internal listener	**AWS::ElasticLoadBalancingV2::Listener**	A listener on port 6443 for the internal load balancer.
Internal target group	**AWS::ElasticLoadBalancingV2::TargetGroup**	The target group for the internal load balancer.

Security groups

The control plane and worker machines require access to the following ports:

Group	Type	IP Protocol	Port range
MasterSecurityGroup	**AWS::EC2::SecurityGroup**	**icmp**	**0**
		tcp	**22**
		tcp	**6443**
		tcp	**22623**
WorkerSecurityGroup	**AWS::EC2::SecurityGroup**	**icmp**	**0**
		tcp	**22**
BootstrapSecurityGroup	**AWS::EC2::SecurityGroup**	**tcp**	**22**
		tcp	**19531**

Control plane Ingress

The control plane machines require the following Ingress groups. Each Ingress group is a **AWS::EC2::SecurityGroupIngress** resource.

Ingress group	Description	IP protocol	Port range
MasterIngressEtcd	etcd	**tcp**	**2379- 2380**
MasterIngressVxlan	Vxlan packets	**udp**	**4789**
MasterIngressWorkerVxlan	Vxlan packets	**udp**	**4789**
MasterIngressInternal	Internal cluster communication and Kubernetes proxy metrics	**tcp**	**9000 - 9999**
MasterIngressWorkerInternal	Internal cluster communication	**tcp**	**9000 - 9999**
MasterIngressKube	Kubernetes kubelet, scheduler and controller manager	**tcp**	**10250 - 10259**
MasterIngressWorkerKube	Kubernetes kubelet, scheduler and controller manager	**tcp**	**10250 - 10259**
MasterIngressIngressServices	Kubernetes Ingress services	**tcp**	**30000 - 32767**
MasterIngressWorkerIngressServices	Kubernetes Ingress services	**tcp**	**30000 - 32767**
MasterIngressGeneve	Geneve packets	**udp**	**6081**
MasterIngressWorkerGeneve	Geneve packets	**udp**	**6081**
MasterIngressIpsecIke	IPsec IKE packets	**udp**	**500**
MasterIngressWorkerIpsecIke	IPsec IKE packets	**udp**	**500**
MasterIngressIpsecNat	IPsec NAT-T packets	**udp**	**4500**

Ingress group	Description	IP protocol	Port range
MasterIngressWorkerIpsecNat	IPsec NAT-T packets	**udp**	**4500**
MasterIngressIpsecEsp	IPsec ESP packets	**50**	**All**
MasterIngressWorkerIpsecEsp	IPsec ESP packets	**50**	**All**
MasterIngressInternalUDP	Internal cluster communication	**udp**	**9000 - 9999**
MasterIngressWorkerInternalUDP	Internal cluster communication	**udp**	**9000 - 9999**
MasterIngressIngressServicesUDP	Kubernetes Ingress services	**udp**	**30000 - 32767**
MasterIngressWorkerIngressServicesUDP	Kubernetes Ingress services	**udp**	**30000 - 32767**

Worker Ingress

The worker machines require the following Ingress groups. Each Ingress group is a **AWS::EC2::SecurityGroupIngress** resource.

Ingress group	Description	IP protocol	Port range
WorkerIngressVxlan	Vxlan packets	**udp**	**4789**
WorkerIngressWorkerVxlan	Vxlan packets	**udp**	**4789**
WorkerIngressInternal	Internal cluster communication	**tcp**	**9000 - 9999**
WorkerIngressWorkerInternal	Internal cluster communication	**tcp**	**9000 - 9999**

Ingress group	Description	IP protocol	Port range
WorkerIngressKube	Kubernetes kubelet, scheduler, and controller manager	**tcp**	**10250**
WorkerIngressWorkerKube	Kubernetes kubelet, scheduler, and controller manager	**tcp**	**10250**
WorkerIngressIngressServices	Kubernetes Ingress services	**tcp**	**30000** - **32767**
WorkerIngressWorkerIngressServices	Kubernetes Ingress services	**tcp**	**30000** - **32767**
WorkerIngressGeneve	Geneve packets	**udp**	**6081**
WorkerIngressMasterGeneve	Geneve packets	**udp**	**6081**
WorkerIngressIpsecIke	IPsec IKE packets	**udp**	**500**
WorkerIngressMasterIpsecIke	IPsec IKE packets	**udp**	**500**
WorkerIngressIpsecNat	IPsec NAT-T packets	**udp**	**4500**
WorkerIngressMasterIpsecNat	IPsec NAT-T packets	**udp**	**4500**
WorkerIngressIpsecEsp	IPsec ESP packets	**50**	**All**
WorkerIngressMasterIpsecEsp	IPsec ESP packets	**50**	**All**
WorkerIngressInternalUDP	Internal cluster communication	**udp**	**9000** - **9999**
WorkerIngressMasterInternalUDP	Internal cluster communication	**udp**	**9000** - **9999**

Ingress group	Description	IP protocol	Port range
WorkerIngressIngressServicesUDP	Kubernetes Ingress services	**udp**	**30000 - 32767**
WorkerIngressMasterIngressServicesUDP	Kubernetes Ingress services	**udp**	**30000 - 32767**

Roles and instance profiles

You must grant the machines permissions in AWS. The provided CloudFormation templates grant the machines **Allow** permissions for the following **AWS::IAM::Role** objects and provide a **AWS::IAM::InstanceProfile** for each set of roles. If you do not use the templates, you can grant the machines the following broad permissions or the following individual permissions.

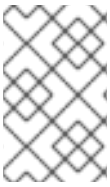
Role	Effect	Action	Resource
Master	**Allow**	**ec2:***	*
	Allow	**elasticloadbalancing:***	*
	Allow	**iam:PassRole**	*
	Allow	**s3:GetObject**	*
Worker	**Allow**	**ec2:Describe***	*
Bootstrap	**Allow**	**ec2:Describe***	*
	Allow	**ec2:AttachVolume**	*
	Allow	**ec2:DetachVolume**	*

5.14.5.2. Cluster machines

You need **AWS::EC2::Instance** objects for the following machines:

- A bootstrap machine. This machine is required during installation, but you can remove it after your cluster deploys.
- Three control plane machines. The control plane machines are not governed by a machine set.
- Compute machines. You must create at least two compute machines, which are also known as worker machines, during installation. These machines are not governed by a machine set.

5.14.5.3. Required AWS permissions for the IAM user



NOTE

Your IAM user must have the permission **tag:GetResources** in the region **us-east-1** to delete the base cluster resources. As part of the AWS API requirement, the OpenShift Container Platform installation program performs various actions in this region.

When you attach the **AdministratorAccess** policy to the IAM user that you create in Amazon Web Services (AWS), you grant that user all of the required permissions. To deploy all components of an OpenShift Container Platform cluster, the IAM user requires the following permissions:

Example 5.52. Required EC2 permissions for installation

- **ec2:AuthorizeSecurityGroupEgress**
- **ec2:AuthorizeSecurityGroupIngress**
- **ec2:CopyImage**
- **ec2:CreateNetworkInterface**
- **ec2:AttachNetworkInterface**
- **ec2:CreateSecurityGroup**
- **ec2:CreateTags**
- **ec2:CreateVolume**
- **ec2:DeleteSecurityGroup**
- **ec2:DeleteSnapshot**
- **ec2:DeleteTags**
- **ec2:DeregisterImage**
- **ec2:DescribeAccountAttributes**
- **ec2:DescribeAddresses**
- **ec2:DescribeAvailabilityZones**
- **ec2:DescribeDhcpOptions**
- **ec2:DescribeImages**
- **ec2:DescribeInstanceAttribute**
- **ec2:DescribeInstanceCreditSpecifications**
- **ec2:DescribeInstances**
- **ec2:DescribeInstanceTypes**
- **ec2:DescribeInternetGateways**
- **ec2:DescribeKeyPairs**

- **ec2:DescribeNatGateways**
- **ec2:DescribeNetworkAcls**
- **ec2:DescribeNetworkInterfaces**
- **ec2:DescribePrefixLists**
- **ec2:DescribeRegions**
- **ec2:DescribeRouteTables**
- **ec2:DescribeSecurityGroups**
- **ec2:DescribeSubnets**
- **ec2:DescribeTags**
- **ec2:DescribeVolumes**
- **ec2:DescribeVpcAttribute**
- **ec2:DescribeVpcClassicLink**
- **ec2:DescribeVpcClassicLinkDnsSupport**
- **ec2:DescribeVpcEndpoints**
- **ec2:DescribeVpcs**
- **ec2:GetEbsDefaultKmsKeyId**
- **ec2:ModifyInstanceAttribute**
- **ec2:ModifyNetworkInterfaceAttribute**
- **ec2:RevokeSecurityGroupEgress**
- **ec2:RevokeSecurityGroupIngress**
- **ec2:RunInstances**
- **ec2:TerminateInstances**

Example 5.53. Required permissions for creating network resources during installation

- **ec2:AllocateAddress**
- **ec2:AssociateAddress**
- **ec2:AssociateDhcpOptions**
- **ec2:AssociateRouteTable**
- **ec2:AttachInternetGateway**
- **ec2:CreateDhcpOptions**

- **ec2:CreateInternetGateway**
- **ec2:CreateNatGateway**
- **ec2:CreateRoute**
- **ec2:CreateRouteTable**
- **ec2:CreateSubnet**
- **ec2:CreateVpc**
- **ec2:CreateVpcEndpoint**
- **ec2:ModifySubnetAttribute**
- **ec2:ModifyVpcAttribute**

NOTE

If you use an existing VPC, your account does not require these permissions for creating network resources.

Example 5.54. Required Elastic Load Balancing permissions (ELB) for installation

- **elasticloadbalancing:AddTags**
- **elasticloadbalancing:ApplySecurityGroupsToLoadBalancer**
- **elasticloadbalancing:AttachLoadBalancerToSubnets**
- **elasticloadbalancing:ConfigureHealthCheck**
- **elasticloadbalancing:CreateLoadBalancer**
- **elasticloadbalancing:CreateLoadBalancerListeners**
- **elasticloadbalancing:DeleteLoadBalancer**
- **elasticloadbalancing:DeregisterInstancesFromLoadBalancer**
- **elasticloadbalancing:DescribeInstanceHealth**
- **elasticloadbalancing:DescribeLoadBalancerAttributes**
- **elasticloadbalancing:DescribeLoadBalancers**
- **elasticloadbalancing:DescribeTags**
- **elasticloadbalancing:ModifyLoadBalancerAttributes**
- **elasticloadbalancing:RegisterInstancesWithLoadBalancer**
- **elasticloadbalancing:SetLoadBalancerPoliciesOfListener**

Example 5.55. Required Elastic Load Balancing permissions (ELBv2) for installation

- **elasticloadbalancing:AddTags**
- **elasticloadbalancing:CreateListener**
- **elasticloadbalancing:CreateLoadBalancer**
- **elasticloadbalancing:CreateTargetGroup**
- **elasticloadbalancing:DeleteLoadBalancer**
- **elasticloadbalancing:DeregisterTargets**
- **elasticloadbalancing:DescribeListeners**
- **elasticloadbalancing:DescribeLoadBalancerAttributes**
- **elasticloadbalancing:DescribeLoadBalancers**
- **elasticloadbalancing:DescribeTargetGroupAttributes**
- **elasticloadbalancing:DescribeTargetHealth**
- **elasticloadbalancing:ModifyLoadBalancerAttributes**
- **elasticloadbalancing:ModifyTargetGroup**
- **elasticloadbalancing:ModifyTargetGroupAttributes**
- **elasticloadbalancing:RegisterTargets**

Example 5.56. Required IAM permissions for installation

- **iam:AddRoleToInstanceProfile**
- **iam:CreateInstanceProfile**
- **iam:CreateRole**
- **iam:DeleteInstanceProfile**
- **iam:DeleteRole**
- **iam:DeleteRolePolicy**
- **iam:GetInstanceProfile**
- **iam:GetRole**
- **iam:GetRolePolicy**
- **iam:GetUser**
- **iam:ListInstanceProfilesForRole**

- **iam:ListRoles**
- **iam:ListUsers**
- **iam:PassRole**
- **iam:PutRolePolicy**
- **iam:RemoveRoleFromInstanceProfile**
- **iam:SimulatePrincipalPolicy**
- **iam:TagRole**

NOTE

If you have not created an elastic load balancer (ELB) in your AWS account, the IAM user also requires the **iam:CreateServiceLinkedRole** permission.

Example 5.57. Required Route 53 permissions for installation

- **route53:ChangeResourceRecordSets**
- **route53:ChangeTagsForResource**
- **route53:CreateHostedZone**
- **route53:DeleteHostedZone**
- **route53:GetChange**
- **route53:GetHostedZone**
- **route53:ListHostedZones**
- **route53:ListHostedZonesByName**
- **route53:ListResourceRecordSets**
- **route53:ListTagsForResource**
- **route53:UpdateHostedZoneComment**

Example 5.58. Required S3 permissions for installation

- **s3:CreateBucket**
- **s3:DeleteBucket**
- **s3:GetAccelerateConfiguration**
- **s3:GetBucketAcl**
- **s3:GetBucketCors**

- **s3:GetBucketLocation**
- **s3:GetBucketLogging**
- **s3:GetBucketPolicy**
- **s3:GetBucketObjectLockConfiguration**
- **s3:GetBucketReplication**
- **s3:GetBucketRequestPayment**
- **s3:GetBucketTagging**
- **s3:GetBucketVersioning**
- **s3:GetBucketWebsite**
- **s3:GetEncryptionConfiguration**
- **s3:GetLifecycleConfiguration**
- **s3:GetReplicationConfiguration**
- **s3:ListBucket**
- **s3:PutBucketAcl**
- **s3:PutBucketTagging**
- **s3:PutEncryptionConfiguration**

Example 5.59. S3 permissions that cluster Operators require

- **s3:DeleteObject**
- **s3:GetObject**
- **s3:GetObjectAcl**
- **s3:GetObjectTagging**
- **s3:GetObjectVersion**
- **s3:PutObject**
- **s3:PutObjectAcl**
- **s3:PutObjectTagging**

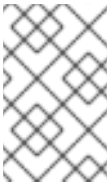
Example 5.60. Required permissions to delete base cluster resources

- **autoscaling:DescribeAutoScalingGroups**
- **ec2:DeletePlacementGroup**

- **ec2:DeleteNetworkInterface**
- **ec2:DeleteVolume**
- **elasticloadbalancing:DeleteTargetGroup**
- **elasticloadbalancing:DescribeTargetGroups**
- **iam:DeleteAccessKey**
- **iam:DeleteUser**
- **iam:ListAttachedRolePolicies**
- **iam:ListInstanceProfiles**
- **iam:ListRolePolicies**
- **iam:ListUserPolicies**
- **s3:DeleteObject**
- **s3:ListBucketVersions**
- **tag:GetResources**

Example 5.61. Required permissions to delete network resources

- **ec2:DeleteDhcpOptions**
- **ec2:DeleteInternetGateway**
- **ec2:DeleteNatGateway**
- **ec2:DeleteRoute**
- **ec2:DeleteRouteTable**
- **ec2:DeleteSubnet**
- **ec2:DeleteVpc**
- **ec2:DeleteVpcEndpoints**
- **ec2:DetachInternetGateway**
- **ec2:DisassociateRouteTable**
- **ec2:ReleaseAddress**
- **ec2:ReplaceRouteTableAssociation**



NOTE

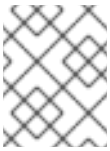
If you use an existing VPC, your account does not require these permissions to delete network resources. Instead, your account only requires the **tag:UntagResources** permission to delete network resources.

Example 5.62. Required permissions to delete a cluster with shared instance roles

- **iam:UntagRole**

Example 5.63. Additional IAM and S3 permissions that are required to create manifests

- **iam:DeleteAccessKey**
- **iam:DeleteUser**
- **iam:DeleteUserPolicy**
- **iam:GetUserPolicy**
- **iam:ListAccessKeys**
- **iam:PutUserPolicy**
- **iam:TagUser**
- **s3:PutBucketPublicAccessBlock**
- **s3:GetBucketPublicAccessBlock**
- **s3:PutLifecycleConfiguration**
- **s3:HeadBucket**
- **s3:ListBucketMultipartUploads**
- **s3:AbortMultipartUpload**



NOTE

If you are managing your cloud provider credentials with mint mode, the IAM user also requires the **iam:CreateAccessKey** and **iam:CreateUser** permissions.

Example 5.64. Optional permissions for instance and quota checks for installation

- **ec2:DescribeInstanceTypeOfferings**
- **servicequotas:ListAWSDefaultServiceQuotas**

5.14.6. Generating a key pair for cluster node SSH access

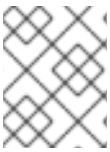
During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the **~/.ssh/authorized_keys** list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The **./openshift-install gather** command also requires the SSH public key to be in place on the cluster nodes.

IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.



NOTE

You must use a local key, not one that you configured with platform-specific approaches such as AWS key pairs.

Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N '' -f <path>/<file_name> 1
```

1 Specify the path and file name, such as **~/.ssh/id_ed25519**, of the new SSH key. If you have an existing key pair, ensure your public key is in the your **~/.ssh** directory.

NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS validated or Modules In Process cryptographic libraries on the **x86_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

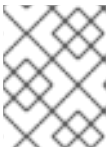
2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the **~/.ssh/id_ed25519.pub** public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the **./openshift-install gather** command.



NOTE

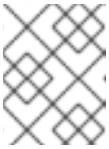
On some distributions, default SSH private key identities such as **~/.ssh/id_rsa** and **~/.ssh/id_dsa** are managed automatically.

a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

Example output

```
Agent pid 31874
```



NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

1 Specify the path and file name for your SSH private key, such as **~/.ssh/id_ed25519**

Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program. If you install a cluster on infrastructure that you provision, you must provide the key to the installation program.

5.14.7. Creating the installation files for AWS

To install OpenShift Container Platform on Amazon Web Services (AWS) using user-provisioned infrastructure, you must generate the files that the installation program needs to deploy your cluster and modify them so that the cluster creates only the machines that it will use. You generate and customize the **install-config.yaml** file, Kubernetes manifests, and Ignition config files. You also have the option to first set up a separate **var** partition during the preparation phases of installation.

5.14.7.1. Optional: Creating a separate /var partition

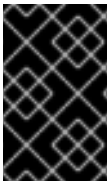
It is recommended that disk partitioning for OpenShift Container Platform be left to the installer. However, there are cases where you might want to create separate partitions in a part of the filesystem that you expect to grow.

OpenShift Container Platform supports the addition of a single partition to attach storage to either the **/var** partition or a subdirectory of **/var**. For example:

- **/var/lib/containers**: Holds container-related content that can grow as more images and containers are added to a system.
- **/var/lib/etcd**: Holds data that you might want to keep separate for purposes such as performance optimization of etcd storage.
- **/var**: Holds data that you might want to keep separate for purposes such as auditing.

Storing the contents of a **/var** directory separately makes it easier to grow storage for those areas as needed and reinstall OpenShift Container Platform at a later date and keep that data intact. With this method, you will not have to pull all your containers again, nor will you have to copy massive log files when you update systems.

Because **/var** must be in place before a fresh installation of Red Hat Enterprise Linux CoreOS (RHCOS), the following procedure sets up the separate **/var** partition by creating a machine config manifest that is inserted during the **openshift-install** preparation phases of an OpenShift Container Platform installation.



IMPORTANT

If you follow the steps to create a separate **/var** partition in this procedure, it is not necessary to create the Kubernetes manifest and Ignition config files again as described later in this section.

Procedure

1. Create a directory to hold the OpenShift Container Platform installation files:

```
$ mkdir $HOME/clusterconfig
```

2. Run **openshift-install** to create a set of files in the **manifest** and **openshift** subdirectories. Answer the system questions as you are prompted:

```
$ openshift-install create manifests --dir $HOME/clusterconfig
```

Example output

```
? SSH Public Key ...
INFO Credentials loaded from the "myprofile" profile in file "/home/myuser/.aws/credentials"
INFO Consuming Install Config from target directory
INFO Manifests created in: $HOME/clusterconfig/manifests and
$HOME/clusterconfig/openshift
```

3. Optional: Confirm that the installation program created manifests in the **clusterconfig/openshift** directory:

```
$ ls $HOME/clusterconfig/openshift/
```

Example output

```
99_kubeadmin-password-secret.yaml
99_openshift-cluster-api_master-machines-0.yaml
99_openshift-cluster-api_master-machines-1.yaml
99_openshift-cluster-api_master-machines-2.yaml
...
```

4. Create a Butane config that configures the additional partition. For example, name the file **$HOME/clusterconfig/98-var-partition.bu**, change the disk device name to the name of the storage device on the **worker** systems, and set the storage size as appropriate. This example places the **/var** directory on a separate partition:

```
variant: openshift
version: 4.11.0
metadata:
  labels:
    machineconfiguration.openshift.io/role: worker
  name: 98-var-partition
storage:
  disks:
  - device: /dev/<device_name> 1
    partitions:
    - label: var
      start_mib: <partition_start_offset> 2
      size_mib: <partition_size> 3
  filesystems:
    - device: /dev/disk/by-partlabel/var
      path: /var
      format: xfs
      mount_options: [defaults, prjquota] 4
      with_mount_unit: true
```

1. The storage device name of the disk that you want to partition.
2. When adding a data partition to the boot disk, a minimum value of 25000 MiB (Mebibytes) is recommended. The root file system is automatically resized to fill all available space up to the specified offset. If no value is specified, or if the specified value is smaller than the recommended minimum, the resulting root file system will be too small, and future reinstalls of RHCOS might overwrite the beginning of the data partition.
3. The size of the data partition in mebibytes.
4. The **prjquota** mount option must be enabled for filesystems used for container storage.

NOTE

When creating a separate **/var** partition, you cannot use different instance types for worker nodes, if the different instance types do not have the same device name.

5. Create a manifest from the Butane config and save it to the **clusterconfig/openshift** directory. For example, run the following command:

```
$ butane $HOME/clusterconfig/98-var-partition.bu -o $HOME/clusterconfig/openshift/98-var-partition.yaml
```

6. Run **openshift-install** again to create Ignition configs from a set of files in the **manifest** and **openshift** subdirectories:

```
$ openshift-install create ignition-configs --dir $HOME/clusterconfig
$ ls $HOME/clusterconfig/
auth  bootstrap.ign  master.ign  metadata.json  worker.ign
```

Now you can use the Ignition config files as input to the installation procedures to install Red Hat Enterprise Linux CoreOS (RHCOS) systems.

5.14.7.2. Creating the installation configuration file

Generate and customize the installation configuration file that the installation program needs to deploy your cluster.

Prerequisites

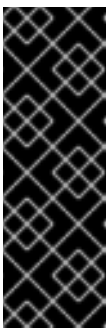
- You obtained the OpenShift Container Platform installation program for user-provisioned infrastructure and the pull secret for your cluster. For a restricted network installation, these files are on your mirror host.
- You checked that you are deploying your cluster to a region with an accompanying Red Hat Enterprise Linux CoreOS (RHCOS) AMI published by Red Hat. If you are deploying to a region that requires a custom AMI, such as an AWS GovCloud region, you must create the **install-config.yaml** file manually.

Procedure

1. Create the **install-config.yaml** file.
   a. Change to the directory that contains the installation program and run the following command:

```
$ ./openshift-install create install-config --dir <installation_directory> 1
```

1 For **<installation_directory>**, specify the directory name to store the files that the installation program creates.

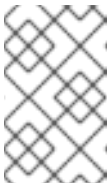


IMPORTANT

Specify an empty directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

   b. At the prompts, provide the configuration details for your cloud:

i. Optional: Select an SSH key to use to access your cluster machines.



NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

ii. Select **aws** as the platform to target.

iii. If you do not have an AWS profile stored on your computer, enter the AWS access key ID and secret access key for the user that you configured to run the installation program.

NOTE

The AWS access key ID and secret access key are stored in **~/.aws/credentials** in the home directory of the current user on the installation host. You are prompted for the credentials by the installation program if the credentials for the exported profile are not present in the file. Any credentials that you provide to the installation program are stored in the file.

iv. Select the AWS region to deploy the cluster to.

v. Select the base domain for the Route 53 service that you configured for your cluster.

vi. Enter a descriptive name for your cluster.

vii. Paste the pull secret from the Red Hat OpenShift Cluster Manager .

2. Edit the **install-config.yaml** file to give the additional information that is required for an installation in a restricted network.

a. Update the **pullSecret** value to contain the authentication information for your registry:

```
pullSecret: '{"auths":{"<local_registry>": {"auth": "<credentials>","email":
"you@example.com"}}}'
```

For **<local_registry>**, specify the registry domain name, and optionally the port, that your mirror registry uses to serve content. For example **registry.example.com** or **registry.example.com:5000**. For **<credentials>**, specify the base64-encoded user name and password for your mirror registry.

b. Add the **additionalTrustBundle** parameter and value. The value must be the contents of the certificate file that you used for your mirror registry. The certificate file can be an existing, trusted certificate authority or the self-signed certificate that you generated for the mirror registry.

```
additionalTrustBundle: |
  -----BEGIN CERTIFICATE-----

ZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZ
  -----END CERTIFICATE-----
```

c. Add the image content resources:

```
imageContentSources:
- mirrors:
  - <local_registry>/<local_repository_name>/release
  source: quay.io/openshift-release-dev/ocp-release
- mirrors:
  - <local_registry>/<local_repository_name>/release
  source: quay.io/openshift-release-dev/ocp-v4.0-art-dev
```

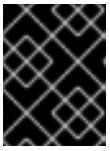
Use the **imageContentSources** section from the output of the command to mirror the repository or the values that you used when you mirrored the content from the media that you brought into your restricted network.

d. Optional: Set the publishing strategy to **Internal**:

```
publish: Internal
```

By setting this option, you create an internal Ingress Controller and a private load balancer.

3. Optional: Back up the **install-config.yaml** file.



IMPORTANT

The **install-config.yaml** file is consumed during the installation process. If you want to reuse the file, you must back it up now.

Additional resources

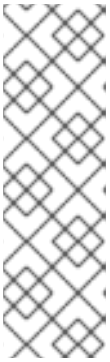
- See Configuration and credential file settings in the AWS documentation for more information about AWS profile and credential configuration.

5.14.7.3. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.



NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

Procedure

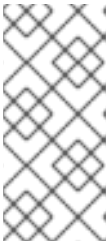
1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: ec2.<region>.amazonaws.com,elasticloadbalancing.
<region>.amazonaws.com,s3.<region>.amazonaws.com 3
additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
```

1. A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
2. A proxy URL to use for creating HTTPS connections outside the cluster.
3. A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use ***** to bypass the proxy for all destinations. If you have added the Amazon **EC2**,**Elastic Load Balancing**, and **S3** VPC endpoints to your VPC, you must add these endpoints to the **noProxy** field.
4. If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace that contains one or more additional CA certificates that are required for proxying HTTPS connections. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges these contents with the Red Hat Enterprise Linux CoreOS (RHCOS) trust bundle, and this config map is referenced in the **trustedCA** field of the **Proxy** object. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.

NOTE

The installation program does not support the proxy **readinessEndpoints** field.



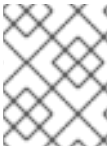
NOTE

If the installer times out, restart and then complete the deployment by using the **wait-for** command of the installer. For example:

```
$ ./openshift-install wait-for install-complete --log-level debug
```

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.



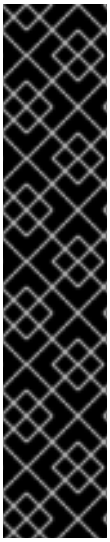
NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

5.14.7.4. Creating the Kubernetes manifest and Ignition config files

Because you must modify some cluster definition files and manually start the cluster machines, you must generate the Kubernetes manifest and Ignition config files that the cluster needs to configure the machines.

The installation configuration file transforms into the Kubernetes manifests. The manifests wrap into the Ignition configuration files, which are later used to configure the cluster machines.



IMPORTANT

- The Ignition config files that the OpenShift Container Platform installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

Prerequisites

- You obtained the OpenShift Container Platform installation program. For a restricted network installation, these files are on your mirror host.
- You created the **install-config.yaml** installation configuration file.

Procedure

1. Change to the directory that contains the OpenShift Container Platform installation program and generate the Kubernetes manifests for the cluster:

```
$ ./openshift-install create manifests --dir <installation_directory> 1
```

1 For **<installation_directory>**, specify the installation directory that contains the **install-config.yaml** file you created.

2. Remove the Kubernetes manifest files that define the control plane machines:

```
$ rm -f <installation_directory>/openshift/99_openshift-cluster-api_master-machines-*.yaml
```

By removing these files, you prevent the cluster from automatically generating control plane machines.

3. Remove the Kubernetes manifest files that define the worker machines:

```
$ rm -f <installation_directory>/openshift/99_openshift-cluster-api_worker-machineset-*.yaml
```

Because you create and manage the worker machines yourself, you do not need to initialize these machines.

4. Check that the **mastersSchedulable** parameter in the **<installation_directory>/manifests/cluster-scheduler-02-config.yml** Kubernetes manifest file is set to **false**. This setting prevents pods from being scheduled on the control plane machines:

   a. Open the **<installation_directory>/manifests/cluster-scheduler-02-config.yml** file.

   b. Locate the **mastersSchedulable** parameter and ensure that it is set to **false**.

   c. Save and exit the file.

5. Optional: If you do not want the Ingress Operator to create DNS records on your behalf, remove the **privateZone** and **publicZone** sections from the **<installation_directory>/manifests/cluster-dns-02-config.yml** DNS configuration file:

```
apiVersion: config.openshift.io/v1
kind: DNS
metadata:
  creationTimestamp: null
  name: cluster
spec:
  baseDomain: example.openshift.com
  privateZone: 1
    id: mycluster-100419-private-zone
  publicZone: 2
    id: example.openshift.com
status: {}
```

1 2 Remove this section completely.

If you do so, you must add ingress DNS records manually in a later step.

6. To create the Ignition configuration files, run the following command from the directory that contains the installation program:

```
$ ./openshift-install create ignition-configs --dir <installation_directory> 1
```

1 For **<installation_directory>**, specify the same installation directory.

Ignition config files are created for the bootstrap, control plane, and compute nodes in the installation directory. The **kubeadmin-password** and **kubeconfig** files are created in the **./<installation_directory>/auth** directory:

```
.
├── auth
│   ├── kubeadmin-password
│   └── kubeconfig
├── bootstrap.ign
├── master.ign
├── metadata.json
└── worker.ign
```

5.14.8. Extracting the infrastructure name

The Ignition config files contain a unique cluster identifier that you can use to uniquely identify your cluster in Amazon Web Services (AWS). The infrastructure name is also used to locate the appropriate AWS resources during an OpenShift Container Platform installation. The provided CloudFormation templates contain references to this infrastructure name, so you must extract it.

Prerequisites

- You obtained the OpenShift Container Platform installation program and the pull secret for your cluster.
- You generated the Ignition config files for your cluster.
- You installed the **jq** package.

Procedure

- To extract and view the infrastructure name from the Ignition config file metadata, run the following command:

```
$ jq -r .infraID <installation_directory>/metadata.json 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

Example output

```
openshift-vw9j6 1
```

1 The output of this command is your cluster name and a random string.

5.14.9. Creating a VPC in AWS

You must create a Virtual Private Cloud (VPC) in Amazon Web Services (AWS) for your OpenShift Container Platform cluster to use. You can customize the VPC to meet your requirements, including VPN and route tables.

You can use the provided CloudFormation template and a custom parameter file to create a stack of AWS resources that represent the VPC.

NOTE

If you do not use the provided CloudFormation template to create your AWS infrastructure, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

Prerequisites

- You configured an AWS account.
- You added your AWS keys and region to your local AWS profile by running **aws configure**.
- You generated the Ignition config files for your cluster.

Procedure

1. Create a JSON file that contains the parameter values that the template requires:

```
[
  {
    "ParameterKey": "VpcCidr", (1)
    "ParameterValue": "10.0.0.0/16" (2)
  },
  {
    "ParameterKey": "AvailabilityZoneCount", (3)
    "ParameterValue": "1" (4)
  },
  {
    "ParameterKey": "SubnetBits", (5)
    "ParameterValue": "12" (6)
  }
]
```

(1) The CIDR block for the VPC.

(2) Specify a CIDR block in the format **x.x.x.x/16-24**.

(3) The number of availability zones to deploy the VPC in.

(4) Specify an integer between **1** and **3**.

(5) The size of each subnet in each availability zone.

(6) Specify an integer between **5** and **13**, where **5** is /**27** and **13** is /**19**.

2. Copy the template from the **CloudFormation template for the VPC**section of this topic and save it as a YAML file on your computer. This template describes the VPC that your cluster requires.

3. Launch the CloudFormation template to create a stack of AWS resources that represent the VPC:

IMPORTANT

You must enter the command on a single line.

```
$ aws cloudformation create-stack --stack-name <name> 1
    --template-body file://<template>.yaml 2
    --parameters file://<parameters>.json 3
```

1 **<name>** is the name for the CloudFormation stack, such as **cluster-vpc**. You need the name of this stack if you remove the cluster.

2 **<template>** is the relative path to and name of the CloudFormation template YAML file that you saved.

3 **<parameters>** is the relative path to and name of the CloudFormation parameters JSON file.

Example output

```
arn:aws:cloudformation:us-east-1:269333783861:stack/cluster-vpc/dbedae40-2fd3-11eb-820e-12a48460849f
```

4. Confirm that the template components exist:

```
$ aws cloudformation describe-stacks --stack-name <name>
```

After the **StackStatus** displays **CREATE_COMPLETE**, the output displays values for the following parameters. You must provide these parameter values to the other CloudFormation templates that you run to create your cluster:

VpcId	The ID of your VPC.
PublicSubnetIds	The IDs of the new public subnets.
PrivateSubnetIds	The IDs of the new private subnets.

5.14.9.1. CloudFormation template for the VPC

You can use the following CloudFormation template to deploy the VPC that you need for your OpenShift Container Platform cluster.

Example 5.65. CloudFormation template for the VPC

```
AWSTemplateFormatVersion: 2010-09-09
Description: Template for Best Practice VPC with 1-3 AZs

Parameters:
  VpcCidr:
    AllowedPattern: ^(([0-9]|[1-9][0-9]|1[0-9]{2}|2[0-4][0-9]|25[0-5])\.){3}([0-9]|[1-9][0-9]|1[0-9]{2}|2[0-
4][0-9]|25[0-5])(\/(1[6-9]|2[0-4]))$
    ConstraintDescription: CIDR block parameter must be in the form x.x.x.x/16-24.
    Default: 10.0.0.0/16
    Description: CIDR block for VPC.
    Type: String
  AvailabilityZoneCount:
    ConstraintDescription: "The number of availability zones. (Min: 1, Max: 3)"
    MinValue: 1
    MaxValue: 3
    Default: 1
    Description: "How many AZs to create VPC subnets for. (Min: 1, Max: 3)"
    Type: Number
  SubnetBits:
    ConstraintDescription: CIDR block parameter must be in the form x.x.x.x/19-27.
    MinValue: 5
    MaxValue: 13
    Default: 12
    Description: "Size of each subnet to create within the availability zones. (Min: 5 = /27, Max: 13 =
/19)"
    Type: Number

Metadata:
  AWS::CloudFormation::Interface:
    ParameterGroups:
    - Label:
        default: "Network Configuration"
      Parameters:
      - VpcCidr
      - SubnetBits
    - Label:
        default: "Availability Zones"
      Parameters:
      - AvailabilityZoneCount
    ParameterLabels:
      AvailabilityZoneCount:
        default: "Availability Zone Count"
      VpcCidr:
        default: "VPC CIDR"
      SubnetBits:
        default: "Bits Per Subnet"

Conditions:
  DoAz3: !Equals [3, !Ref AvailabilityZoneCount]
  DoAz2: !Or [!Equals [2, !Ref AvailabilityZoneCount], Condition: DoAz3]

Resources:
  VPC:
    Type: "AWS::EC2::VPC"
    Properties:
      EnableDnsSupport: "true"
```

```
    EnableDnsHostnames: "true"
    CidrBlock: !Ref VpcCidr
PublicSubnet:
  Type: "AWS::EC2::Subnet"
  Properties:
    VpcId: !Ref VPC
    CidrBlock: !Select [0, !Cidr [!Ref VpcCidr, 6, !Ref SubnetBits]]
    AvailabilityZone: !Select
    - 0
    - Fn::GetAZs: !Ref "AWS::Region"
PublicSubnet2:
  Type: "AWS::EC2::Subnet"
  Condition: DoAz2
  Properties:
    VpcId: !Ref VPC
    CidrBlock: !Select [1, !Cidr [!Ref VpcCidr, 6, !Ref SubnetBits]]
    AvailabilityZone: !Select
    - 1
    - Fn::GetAZs: !Ref "AWS::Region"
PublicSubnet3:
  Type: "AWS::EC2::Subnet"
  Condition: DoAz3
  Properties:
    VpcId: !Ref VPC
    CidrBlock: !Select [2, !Cidr [!Ref VpcCidr, 6, !Ref SubnetBits]]
    AvailabilityZone: !Select
    - 2
    - Fn::GetAZs: !Ref "AWS::Region"
InternetGateway:
  Type: "AWS::EC2::InternetGateway"
GatewayToInternet:
  Type: "AWS::EC2::VPCGatewayAttachment"
  Properties:
    VpcId: !Ref VPC
    InternetGatewayId: !Ref InternetGateway
PublicRouteTable:
  Type: "AWS::EC2::RouteTable"
  Properties:
    VpcId: !Ref VPC
PublicRoute:
  Type: "AWS::EC2::Route"
  DependsOn: GatewayToInternet
  Properties:
    RouteTableId: !Ref PublicRouteTable
    DestinationCidrBlock: 0.0.0.0/0
    GatewayId: !Ref InternetGateway
PublicSubnetRouteTableAssociation:
  Type: "AWS::EC2::SubnetRouteTableAssociation"
  Properties:
    SubnetId: !Ref PublicSubnet
    RouteTableId: !Ref PublicRouteTable
PublicSubnetRouteTableAssociation2:
  Type: "AWS::EC2::SubnetRouteTableAssociation"
  Condition: DoAz2
  Properties:
    SubnetId: !Ref PublicSubnet2
```

```
    RouteTableId: !Ref PublicRouteTable
PublicSubnetRouteTableAssociation3:
  Condition: DoAz3
  Type: "AWS::EC2::SubnetRouteTableAssociation"
  Properties:
    SubnetId: !Ref PublicSubnet3
    RouteTableId: !Ref PublicRouteTable
PrivateSubnet:
  Type: "AWS::EC2::Subnet"
  Properties:
    VpcId: !Ref VPC
    CidrBlock: !Select [3, !Cidr [!Ref VpcCidr, 6, !Ref SubnetBits]]
    AvailabilityZone: !Select
    - 0
    - Fn::GetAZs: !Ref "AWS::Region"
PrivateRouteTable:
  Type: "AWS::EC2::RouteTable"
  Properties:
    VpcId: !Ref VPC
PrivateSubnetRouteTableAssociation:
  Type: "AWS::EC2::SubnetRouteTableAssociation"
  Properties:
    SubnetId: !Ref PrivateSubnet
    RouteTableId: !Ref PrivateRouteTable
NAT:
  DependsOn:
  - GatewayToInternet
  Type: "AWS::EC2::NatGateway"
  Properties:
    AllocationId:
      "Fn::GetAtt":
      - EIP
      - AllocationId
    SubnetId: !Ref PublicSubnet
EIP:
  Type: "AWS::EC2::EIP"
  Properties:
    Domain: vpc
Route:
  Type: "AWS::EC2::Route"
  Properties:
    RouteTableId:
      Ref: PrivateRouteTable
    DestinationCidrBlock: 0.0.0.0/0
    NatGatewayId:
      Ref: NAT
PrivateSubnet2:
  Type: "AWS::EC2::Subnet"
  Condition: DoAz2
  Properties:
    VpcId: !Ref VPC
    CidrBlock: !Select [4, !Cidr [!Ref VpcCidr, 6, !Ref SubnetBits]]
    AvailabilityZone: !Select
    - 1
    - Fn::GetAZs: !Ref "AWS::Region"
PrivateRouteTable2:
```

```
  Type: "AWS::EC2::RouteTable"
  Condition: DoAz2
  Properties:
    VpcId: !Ref VPC
PrivateSubnetRouteTableAssociation2:
  Type: "AWS::EC2::SubnetRouteTableAssociation"
  Condition: DoAz2
  Properties:
    SubnetId: !Ref PrivateSubnet2
    RouteTableId: !Ref PrivateRouteTable2
NAT2:
  DependsOn:
  - GatewayToInternet
  Type: "AWS::EC2::NatGateway"
  Condition: DoAz2
  Properties:
    AllocationId:
      "Fn::GetAtt":
      - EIP2
      - AllocationId
    SubnetId: !Ref PublicSubnet2
EIP2:
  Type: "AWS::EC2::EIP"
  Condition: DoAz2
  Properties:
    Domain: vpc
Route2:
  Type: "AWS::EC2::Route"
  Condition: DoAz2
  Properties:
    RouteTableId:
      Ref: PrivateRouteTable2
    DestinationCidrBlock: 0.0.0.0/0
    NatGatewayId:
      Ref: NAT2
PrivateSubnet3:
  Type: "AWS::EC2::Subnet"
  Condition: DoAz3
  Properties:
    VpcId: !Ref VPC
    CidrBlock: !Select [5, !Cidr [!Ref VpcCidr, 6, !Ref SubnetBits]]
    AvailabilityZone: !Select
    - 2
    - Fn::GetAZs: !Ref "AWS::Region"
PrivateRouteTable3:
  Type: "AWS::EC2::RouteTable"
  Condition: DoAz3
  Properties:
    VpcId: !Ref VPC
PrivateSubnetRouteTableAssociation3:
  Type: "AWS::EC2::SubnetRouteTableAssociation"
  Condition: DoAz3
  Properties:
    SubnetId: !Ref PrivateSubnet3
    RouteTableId: !Ref PrivateRouteTable3
NAT3:
```

```
    DependsOn:
    - GatewayToInternet
    Type: "AWS::EC2::NatGateway"
    Condition: DoAz3
    Properties:
      AllocationId:
        "Fn::GetAtt":
        - EIP3
        - AllocationId
      SubnetId: !Ref PublicSubnet3
  EIP3:
    Type: "AWS::EC2::EIP"
    Condition: DoAz3
    Properties:
      Domain: vpc
  Route3:
    Type: "AWS::EC2::Route"
    Condition: DoAz3
    Properties:
      RouteTableId:
        Ref: PrivateRouteTable3
      DestinationCidrBlock: 0.0.0.0/0
      NatGatewayId:
        Ref: NAT3
  S3Endpoint:
    Type: AWS::EC2::VPCEndpoint
    Properties:
      PolicyDocument:
        Version: 2012-10-17
        Statement:
        - Effect: Allow
          Principal: '*'
          Action:
          - '*'
          Resource:
          - '*'
      RouteTableIds:
      - !Ref PublicRouteTable
      - !Ref PrivateRouteTable
      - !If [DoAz2, !Ref PrivateRouteTable2, !Ref "AWS::NoValue"]
      - !If [DoAz3, !Ref PrivateRouteTable3, !Ref "AWS::NoValue"]
      ServiceName: !Join
      - ''
      - - com.amazonaws.
        - !Ref 'AWS::Region'
        - .s3
      VpcId: !Ref VPC

Outputs:
  VpcId:
    Description: ID of the new VPC.
    Value: !Ref VPC
  PublicSubnetIds:
    Description: Subnet IDs of the public subnets.
    Value:
      !Join [
```

```
        ",",
        [!Ref PublicSubnet, !If [DoAz2, !Ref PublicSubnet2, !Ref "AWS::NoValue"], !If [DoAz3, !Ref
PublicSubnet3, !Ref "AWS::NoValue"]]
      ]
  PrivateSubnetIds:
    Description: Subnet IDs of the private subnets.
    Value:
      !Join [
        ",",
        [!Ref PrivateSubnet, !If [DoAz2, !Ref PrivateSubnet2, !Ref "AWS::NoValue"], !If [DoAz3, !Ref
PrivateSubnet3, !Ref "AWS::NoValue"]]
      ]
```

5.14.10. Creating networking and load balancing components in AWS

You must configure networking and classic or network load balancing in Amazon Web Services (AWS) that your OpenShift Container Platform cluster can use.

You can use the provided CloudFormation template and a custom parameter file to create a stack of AWS resources. The stack represents the networking and load balancing components that your OpenShift Container Platform cluster requires. The template also creates a hosted zone and subnet tags.

You can run the template multiple times within a single Virtual Private Cloud (VPC).

NOTE

If you do not use the provided CloudFormation template to create your AWS infrastructure, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

Prerequisites

- You configured an AWS account.
- You added your AWS keys and region to your local AWS profile by running **aws configure**.
- You generated the Ignition config files for your cluster.
- You created and configured a VPC and associated subnets in AWS.

Procedure

1. Obtain the hosted zone ID for the Route 53 base domain that you specified in the **install-config.yaml** file for your cluster. You can obtain details about your hosted zone by running the following command:

```
$ aws route53 list-hosted-zones-by-name --dns-name <route53_domain> 1
```

1 For the **<route53_domain>**, specify the Route 53 base domain that you used when you generated the **install-config.yaml** file for the cluster.

Example output

```
mycluster.example.com. False 100
HOSTEDZONES 65F8F38E-2268-B835-E15C-AB55336FCBFA
/hostedzone/Z21IXYZABCZ2A4 mycluster.example.com. 10
```

In the example output, the hosted zone ID is **Z21IXYZABCZ2A4**.

2. Create a JSON file that contains the parameter values that the template requires:

```
[
  {
    "ParameterKey": "ClusterName", (1)
    "ParameterValue": "mycluster" (2)
  },
  {
    "ParameterKey": "InfrastructureName", (3)
    "ParameterValue": "mycluster-<random_string>" (4)
  },
  {
    "ParameterKey": "HostedZoneId", (5)
    "ParameterValue": "<random_string>" (6)
  },
  {
    "ParameterKey": "HostedZoneName", (7)
    "ParameterValue": "example.com" (8)
  },
  {
    "ParameterKey": "PublicSubnets", (9)
    "ParameterValue": "subnet-<random_string>" (10)
  },
  {
    "ParameterKey": "PrivateSubnets", (11)
    "ParameterValue": "subnet-<random_string>" (12)
  },
  {
    "ParameterKey": "VpcId", (13)
    "ParameterValue": "vpc-<random_string>" (14)
  }
]
```

(1) A short, representative cluster name to use for hostnames, etc.

(2) Specify the cluster name that you used when you generated the **install-config.yaml** file for the cluster.

(3) The name for your cluster infrastructure that is encoded in your Ignition config files for the cluster.

(4) Specify the infrastructure name that you extracted from the Ignition config file metadata, which has the format **<cluster-name>-<random-string>**.

(5) The Route 53 public zone ID to register the targets with.

6 Specify the Route 53 public zone ID, which as a format similar to **Z21IXYZABCZ2A4**. You can obtain this value from the AWS console.

7 The Route 53 zone to register the targets with.

8 Specify the Route 53 base domain that you used when you generated the **install-config.yaml** file for the cluster. Do not include the trailing period (.) that is displayed in the AWS console.

9 The public subnets that you created for your VPC.

10 Specify the **PublicSubnetIds** value from the output of the CloudFormation template for the VPC.

11 The private subnets that you created for your VPC.

12 Specify the **PrivateSubnetIds** value from the output of the CloudFormation template for the VPC.

13 The VPC that you created for the cluster.

14 Specify the **VpcId** value from the output of the CloudFormation template for the VPC.

3. Copy the template from the **CloudFormation template for the network and load balancers** section of this topic and save it as a YAML file on your computer. This template describes the networking and load balancing objects that your cluster requires.

IMPORTANT

If you are deploying your cluster to an AWS government or secret region, you must update the **InternalApiServerRecord** in the CloudFormation template to use **CNAME** records. Records of type **ALIAS** are not supported for AWS government regions.

4. Launch the CloudFormation template to create a stack of AWS resources that provide the networking and load balancing components:

IMPORTANT

You must enter the command on a single line.

```
$ aws cloudformation create-stack --stack-name <name> 1
    --template-body file://<template>.yaml 2
    --parameters file://<parameters>.json 3
    --capabilities CAPABILITY_NAMED_IAM 4
```

1 **<name>** is the name for the CloudFormation stack, such as **cluster-dns**. You need the name of this stack if you remove the cluster.

2 **<template>** is the relative path to and name of the CloudFormation template YAML file that you saved.

3

<parameters> is the relative path to and name of the CloudFormation parameters JSON file.

4 You must explicitly declare the **CAPABILITY_NAMED_IAM** capability because the provided template creates some **AWS::IAM::Role** resources.

Example output

```
arn:aws:cloudformation:us-east-1:269333783861:stack/cluster-dns/cd3e5de0-2fd4-11eb-5cf0-12be5c33a183
```

5. Confirm that the template components exist:

```
$ aws cloudformation describe-stacks --stack-name <name>
```

After the **StackStatus** displays **CREATE_COMPLETE**, the output displays values for the following parameters. You must provide these parameter values to the other CloudFormation templates that you run to create your cluster:

PrivateHostedZoneId	Hosted zone ID for the private DNS.
ExternalApiLoadBalancerName	Full name of the external API load balancer.
InternalApiLoadBalancerName	Full name of the internal API load balancer.
ApiServerDnsName	Full hostname of the API server.
RegisterNlbIpTargetsLambda	Lambda ARN useful to help register/deregister IP targets for these load balancers.
ExternalApiTargetGroupArn	ARN of external API target group.
InternalApiTargetGroupArn	ARN of internal API target group.
InternalServiceTargetGroupArn	ARN of internal service target group.

5.14.10.1. CloudFormation template for the network and load balancers

You can use the following CloudFormation template to deploy the networking objects and load balancers that you need for your OpenShift Container Platform cluster.

Example 5.66. CloudFormation template for the network and load balancers

```
AWSTemplateFormatVersion: 2010-09-09
Description: Template for OpenShift Cluster Network Elements (Route53 & LBs)

Parameters:
  ClusterName:
    AllowedPattern: ^([a-zA-Z][a-zA-Z0-9\-]{0,26})$
    MaxLength: 27
    MinLength: 1
    ConstraintDescription: Cluster name must be alphanumeric, start with a letter, and have a
maximum of 27 characters.
    Description: A short, representative cluster name to use for host names and other identifying
names.
    Type: String
  InfrastructureName:
    AllowedPattern: ^([a-zA-Z][a-zA-Z0-9\-]{0,26})$
    MaxLength: 27
    MinLength: 1
    ConstraintDescription: Infrastructure name must be alphanumeric, start with a letter, and have a
maximum of 27 characters.
    Description: A short, unique cluster ID used to tag cloud resources and identify items owned or
used by the cluster.
    Type: String
  HostedZoneId:
    Description: The Route53 public zone ID to register the targets with, such as
Z21IXYZABCZ2A4.
    Type: String
  HostedZoneName:
    Description: The Route53 zone to register the targets with, such as example.com. Omit the
trailing period.
    Type: String
    Default: "example.com"
  PublicSubnets:
    Description: The internet-facing subnets.
    Type: List<AWS::EC2::Subnet::Id>
  PrivateSubnets:
    Description: The internal subnets.
    Type: List<AWS::EC2::Subnet::Id>
  VpcId:
    Description: The VPC-scoped resources will belong to this VPC.
    Type: AWS::EC2::VPC::Id

Metadata:
  AWS::CloudFormation::Interface:
    ParameterGroups:
    - Label:
        default: "Cluster Information"
      Parameters:
      - ClusterName
      - InfrastructureName
```

```
    - Label:
        default: "Network Configuration"
      Parameters:
      - VpcId
      - PublicSubnets
      - PrivateSubnets
    - Label:
        default: "DNS"
      Parameters:
      - HostedZoneName
      - HostedZoneId
    ParameterLabels:
      ClusterName:
        default: "Cluster Name"
      InfrastructureName:
        default: "Infrastructure Name"
      VpcId:
        default: "VPC ID"
      PublicSubnets:
        default: "Public Subnets"
      PrivateSubnets:
        default: "Private Subnets"
      HostedZoneName:
        default: "Public Hosted Zone Name"
      HostedZoneId:
        default: "Public Hosted Zone ID"

Resources:
  ExtApiElb:
    Type: AWS::ElasticLoadBalancingV2::LoadBalancer
    Properties:
      Name: !Join ["-", [!Ref InfrastructureName, "ext"]]
      IpAddressType: ipv4
      Subnets: !Ref PublicSubnets
      Type: network

  IntApiElb:
    Type: AWS::ElasticLoadBalancingV2::LoadBalancer
    Properties:
      Name: !Join ["-", [!Ref InfrastructureName, "int"]]
      Scheme: internal
      IpAddressType: ipv4
      Subnets: !Ref PrivateSubnets
      Type: network

  IntDns:
    Type: "AWS::Route53::HostedZone"
    Properties:
      HostedZoneConfig:
        Comment: "Managed by CloudFormation"
      Name: !Join [".", [!Ref ClusterName, !Ref HostedZoneName]]
      HostedZoneTags:
      - Key: Name
        Value: !Join ["-", [!Ref InfrastructureName, "int"]]
      - Key: !Join ["", ["kubernetes.io/cluster/", !Ref InfrastructureName]]
        Value: "owned"
```

```
      VPCs:
      - VPCId: !Ref VpcId
        VPCRegion: !Ref "AWS::Region"

  ExternalApiServerRecord:
    Type: AWS::Route53::RecordSetGroup
    Properties:
      Comment: Alias record for the API server
      HostedZoneId: !Ref HostedZoneId
      RecordSets:
      - Name:
          !Join [
            ".",
            ["api", !Ref ClusterName, !Join ["", [!Ref HostedZoneName, "."]]],
          ]
        Type: A
        AliasTarget:
          HostedZoneId: !GetAtt ExtApiElb.CanonicalHostedZoneID
          DNSName: !GetAtt ExtApiElb.DNSName

  InternalApiServerRecord:
    Type: AWS::Route53::RecordSetGroup
    Properties:
      Comment: Alias record for the API server
      HostedZoneId: !Ref IntDns
      RecordSets:
      - Name:
          !Join [
            ".",
            ["api", !Ref ClusterName, !Join ["", [!Ref HostedZoneName, "."]]],
          ]
        Type: A
        AliasTarget:
          HostedZoneId: !GetAtt IntApiElb.CanonicalHostedZoneID
          DNSName: !GetAtt IntApiElb.DNSName
      - Name:
          !Join [
            ".",
            ["api-int", !Ref ClusterName, !Join ["", [!Ref HostedZoneName, "."]]],
          ]
        Type: A
        AliasTarget:
          HostedZoneId: !GetAtt IntApiElb.CanonicalHostedZoneID
          DNSName: !GetAtt IntApiElb.DNSName

  ExternalApiListener:
    Type: AWS::ElasticLoadBalancingV2::Listener
    Properties:
      DefaultActions:
      - Type: forward
        TargetGroupArn:
          Ref: ExternalApiTargetGroup
      LoadBalancerArn:
        Ref: ExtApiElb
      Port: 6443
      Protocol: TCP
```

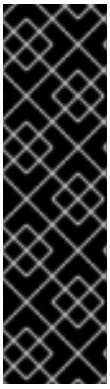
```
ExternalApiTargetGroup:
  Type: AWS::ElasticLoadBalancingV2::TargetGroup
  Properties:
    HealthCheckIntervalSeconds: 10
    HealthCheckPath: "/readyz"
    HealthCheckPort: 6443
    HealthCheckProtocol: HTTPS
    HealthyThresholdCount: 2
    UnhealthyThresholdCount: 2
    Port: 6443
    Protocol: TCP
    TargetType: ip
    VpcId:
      Ref: VpcId
    TargetGroupAttributes:
    - Key: deregistration_delay.timeout_seconds
      Value: 60

InternalApiListener:
  Type: AWS::ElasticLoadBalancingV2::Listener
  Properties:
    DefaultActions:
    - Type: forward
      TargetGroupArn:
        Ref: InternalApiTargetGroup
    LoadBalancerArn:
      Ref: IntApiElb
    Port: 6443
    Protocol: TCP

InternalApiTargetGroup:
  Type: AWS::ElasticLoadBalancingV2::TargetGroup
  Properties:
    HealthCheckIntervalSeconds: 10
    HealthCheckPath: "/readyz"
    HealthCheckPort: 6443
    HealthCheckProtocol: HTTPS
    HealthyThresholdCount: 2
    UnhealthyThresholdCount: 2
    Port: 6443
    Protocol: TCP
    TargetType: ip
    VpcId:
      Ref: VpcId
    TargetGroupAttributes:
    - Key: deregistration_delay.timeout_seconds
      Value: 60

InternalServiceInternalListener:
  Type: AWS::ElasticLoadBalancingV2::Listener
  Properties:
    DefaultActions:
    - Type: forward
      TargetGroupArn:
        Ref: InternalServiceTargetGroup
```

```
      LoadBalancerArn:
        Ref: IntApiElb
      Port: 22623
      Protocol: TCP

  InternalServiceTargetGroup:
    Type: AWS::ElasticLoadBalancingV2::TargetGroup
    Properties:
      HealthCheckIntervalSeconds: 10
      HealthCheckPath: "/healthz"
      HealthCheckPort: 22623
      HealthCheckProtocol: HTTPS
      HealthyThresholdCount: 2
      UnhealthyThresholdCount: 2
      Port: 22623
      Protocol: TCP
      TargetType: ip
      VpcId:
        Ref: VpcId
      TargetGroupAttributes:
      - Key: deregistration_delay.timeout_seconds
        Value: 60

  RegisterTargetLambdaIamRole:
    Type: AWS::IAM::Role
    Properties:
      RoleName: !Join ["-", [!Ref InfrastructureName, "nlb", "lambda", "role"]]
      AssumeRolePolicyDocument:
        Version: "2012-10-17"
        Statement:
        - Effect: "Allow"
          Principal:
            Service:
            - "lambda.amazonaws.com"
          Action:
          - "sts:AssumeRole"
      Path: "/"
      Policies:
      - PolicyName: !Join ["-", [!Ref InfrastructureName, "master", "policy"]]
        PolicyDocument:
          Version: "2012-10-17"
          Statement:
          - Effect: "Allow"
            Action:
              [
                "elasticloadbalancing:RegisterTargets",
                "elasticloadbalancing:DeregisterTargets",
              ]
            Resource: !Ref InternalApiTargetGroup
          - Effect: "Allow"
            Action:
              [
                "elasticloadbalancing:RegisterTargets",
                "elasticloadbalancing:DeregisterTargets",
              ]
            Resource: !Ref InternalServiceTargetGroup
```

```
        - Effect: "Allow"
          Action:
           [
             "elasticloadbalancing:RegisterTargets",
             "elasticloadbalancing:DeregisterTargets",
           ]
          Resource: !Ref ExternalApiTargetGroup

  RegisterNlbIpTargets:
    Type: "AWS::Lambda::Function"
    Properties:
      Handler: "index.handler"
      Role:
        Fn::GetAtt:
        - "RegisterTargetLambdaIamRole"
        - "Arn"
      Code:
        ZipFile: |
          import json
          import boto3
          import cfnresponse
          def handler(event, context):
            elb = boto3.client('elbv2')
            if event['RequestType'] == 'Delete':
              elb.deregister_targets(TargetGroupArn=event['ResourceProperties']
['TargetArn'],Targets=[{'Id': event['ResourceProperties']['TargetIp']}])
            elif event['RequestType'] == 'Create':
              elb.register_targets(TargetGroupArn=event['ResourceProperties']['TargetArn'],Targets=
[{'Id': event['ResourceProperties']['TargetIp']}])
            responseData = {}
            cfnresponse.send(event, context, cfnresponse.SUCCESS, responseData,
event['ResourceProperties']['TargetArn']+event['ResourceProperties']['TargetIp'])
      Runtime: "python3.7"
      Timeout: 120

  RegisterSubnetTagsLambdaIamRole:
    Type: AWS::IAM::Role
    Properties:
      RoleName: !Join ["-", [!Ref InfrastructureName, "subnet-tags-lambda-role"]]
      AssumeRolePolicyDocument:
        Version: "2012-10-17"
        Statement:
        - Effect: "Allow"
          Principal:
            Service:
            - "lambda.amazonaws.com"
          Action:
          - "sts:AssumeRole"
      Path: "/"
      Policies:
      - PolicyName: !Join ["-", [!Ref InfrastructureName, "subnet-tagging-policy"]]
        PolicyDocument:
          Version: "2012-10-17"
          Statement:
          - Effect: "Allow"
            Action:
```

```
            [
              "ec2:DeleteTags",
              "ec2:CreateTags"
            ]
            Resource: "arn:aws:ec2:*:*:subnet/*"
          - Effect: "Allow"
            Action:
            [
              "ec2:DescribeSubnets",
              "ec2:DescribeTags"
            ]
            Resource: "*"

  RegisterSubnetTags:
    Type: "AWS::Lambda::Function"
    Properties:
      Handler: "index.handler"
      Role:
        Fn::GetAtt:
        - "RegisterSubnetTagsLambdaIamRole"
        - "Arn"
      Code:
        ZipFile: |
          import json
          import boto3
          import cfnresponse
          def handler(event, context):
            ec2_client = boto3.client('ec2')
            if event['RequestType'] == 'Delete':
              for subnet_id in event['ResourceProperties']['Subnets']:
                ec2_client.delete_tags(Resources=[subnet_id], Tags=[{'Key': 'kubernetes.io/cluster/' +
event['ResourceProperties']['InfrastructureName']}]);
            elif event['RequestType'] == 'Create':
              for subnet_id in event['ResourceProperties']['Subnets']:
                ec2_client.create_tags(Resources=[subnet_id], Tags=[{'Key': 'kubernetes.io/cluster/' +
event['ResourceProperties']['InfrastructureName'], 'Value': 'shared'}]);
            responseData = {}
            cfnresponse.send(event, context, cfnresponse.SUCCESS, responseData,
event['ResourceProperties']['InfrastructureName']+event['ResourceProperties']['Subnets'][0])
      Runtime: "python3.7"
      Timeout: 120

  RegisterPublicSubnetTags:
    Type: Custom::SubnetRegister
    Properties:
      ServiceToken: !GetAtt RegisterSubnetTags.Arn
      InfrastructureName: !Ref InfrastructureName
      Subnets: !Ref PublicSubnets

  RegisterPrivateSubnetTags:
    Type: Custom::SubnetRegister
    Properties:
      ServiceToken: !GetAtt RegisterSubnetTags.Arn
      InfrastructureName: !Ref InfrastructureName
      Subnets: !Ref PrivateSubnets
```

```
Outputs:
  PrivateHostedZoneId:
    Description: Hosted zone ID for the private DNS, which is required for private records.
    Value: !Ref IntDns
  ExternalApiLoadBalancerName:
    Description: Full name of the external API load balancer.
    Value: !GetAtt ExtApiElb.LoadBalancerFullName
  InternalApiLoadBalancerName:
    Description: Full name of the internal API load balancer.
    Value: !GetAtt IntApiElb.LoadBalancerFullName
  ApiServerDnsName:
    Description: Full hostname of the API server, which is required for the Ignition config files.
    Value: !Join [".", ["api-int", !Ref ClusterName, !Ref HostedZoneName]]
  RegisterNlbIpTargetsLambda:
    Description: Lambda ARN useful to help register or deregister IP targets for these load
balancers.
    Value: !GetAtt RegisterNlbIpTargets.Arn
  ExternalApiTargetGroupArn:
    Description: ARN of the external API target group.
    Value: !Ref ExternalApiTargetGroup
  InternalApiTargetGroupArn:
    Description: ARN of the internal API target group.
    Value: !Ref InternalApiTargetGroup
  InternalServiceTargetGroupArn:
    Description: ARN of the internal service target group.
    Value: !Ref InternalServiceTargetGroup
```



IMPORTANT

If you are deploying your cluster to an AWS government or secret region, you must update the **InternalApiServerRecord** to use **CNAME** records. Records of type **ALIAS** are not supported for AWS government regions. For example:

```
Type: CNAME
TTL: 10
ResourceRecords:
- !GetAtt IntApiElb.DNSName
```

Additional resources

- See Listing public hosted zones in the AWS documentation for more information about listing public hosted zones.

5.14.11. Creating security group and roles in AWS

You must create security groups and roles in Amazon Web Services (AWS) for your OpenShift Container Platform cluster to use.

You can use the provided CloudFormation template and a custom parameter file to create a stack of AWS resources. The stack represents the security groups and roles that your OpenShift Container Platform cluster requires.

NOTE

If you do not use the provided CloudFormation template to create your AWS infrastructure, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

Prerequisites

- You configured an AWS account.
- You added your AWS keys and region to your local AWS profile by running **aws configure**.
- You generated the Ignition config files for your cluster.
- You created and configured a VPC and associated subnets in AWS.

Procedure

1. Create a JSON file that contains the parameter values that the template requires:

```
[
  {
    "ParameterKey": "InfrastructureName", 1
    "ParameterValue": "mycluster-<random_string>" 2
  },
  {
    "ParameterKey": "VpcCidr", 3
    "ParameterValue": "10.0.0.0/16" 4
  },
  {
    "ParameterKey": "PrivateSubnets", 5
    "ParameterValue": "subnet-<random_string>" 6
  },
  {
    "ParameterKey": "VpcId", 7
    "ParameterValue": "vpc-<random_string>" 8
  }
]
```

1. The name for your cluster infrastructure that is encoded in your Ignition config files for the cluster.
2. Specify the infrastructure name that you extracted from the Ignition config file metadata, which has the format **<cluster-name>-<random-string>**.
3. The CIDR block for the VPC.
4. Specify the CIDR block parameter that you used for the VPC that you defined in the form **x.x.x.x/16-24**.
5. The private subnets that you created for your VPC.
6. Specify the **PrivateSubnetIds** value from the output of the CloudFormation template for the VPC.

7 The VPC that you created for the cluster.

8 Specify the **VpcId** value from the output of the CloudFormation template for the VPC.

2. Copy the template from the **CloudFormation template for security objects**section of this topic and save it as a YAML file on your computer. This template describes the security groups and roles that your cluster requires.

3. Launch the CloudFormation template to create a stack of AWS resources that represent the security groups and roles:

IMPORTANT

You must enter the command on a single line.

```
$ aws cloudformation create-stack --stack-name <name> 1
    --template-body file://<template>.yaml 2
    --parameters file://<parameters>.json 3
    --capabilities CAPABILITY_NAMED_IAM 4
```

1 **<name>** is the name for the CloudFormation stack, such as **cluster-sec**. You need the name of this stack if you remove the cluster.

2 **<template>** is the relative path to and name of the CloudFormation template YAML file that you saved.

3 **<parameters>** is the relative path to and name of the CloudFormation parameters JSON file.

4 You must explicitly declare the **CAPABILITY_NAMED_IAM** capability because the provided template creates some **AWS::IAM::Role** and **AWS::IAM::InstanceProfile** resources.

Example output

```
arn:aws:cloudformation:us-east-1:269333783861:stack/cluster-sec/03bd4210-2ed7-11eb-6d7a-13fc0b61e9db
```

4. Confirm that the template components exist:

```
$ aws cloudformation describe-stacks --stack-name <name>
```

After the **StackStatus** displays **CREATE_COMPLETE**, the output displays values for the following parameters. You must provide these parameter values to the other CloudFormation templates that you run to create your cluster:

MasterSecurityGroupId	Master Security Group ID

WorkerSecurityGroupId	Worker Security Group ID
MasterInstanceProfile	Master IAM Instance Profile
WorkerInstanceProfile	Worker IAM Instance Profile

5.14.11.1. CloudFormation template for security objects

You can use the following CloudFormation template to deploy the security objects that you need for your OpenShift Container Platform cluster.

Example 5.67. CloudFormation template for security objects

```
AWSTemplateFormatVersion: 2010-09-09
Description: Template for OpenShift Cluster Security Elements (Security Groups & IAM)

Parameters:
  InfrastructureName:
    AllowedPattern: ^([a-zA-Z][a-zA-Z0-9\-]{0,26})$
    MaxLength: 27
    MinLength: 1
    ConstraintDescription: Infrastructure name must be alphanumeric, start with a letter, and have a
maximum of 27 characters.
    Description: A short, unique cluster ID used to tag cloud resources and identify items owned or
used by the cluster.
    Type: String
  VpcCidr:
    AllowedPattern: ^(([0-9]|[1-9][0-9]|1[0-9]{2}|2[0-4][0-9]|25[0-5])\.){3}([0-9]|[1-9][0-9]|1[0-9]{2}|2[0-
4][0-9]|25[0-5])(\/(1[6-9]|2[0-4]))$
    ConstraintDescription: CIDR block parameter must be in the form x.x.x.x/16-24.
    Default: 10.0.0.0/16
    Description: CIDR block for VPC.
    Type: String
  VpcId:
    Description: The VPC-scoped resources will belong to this VPC.
    Type: AWS::EC2::VPC::Id
  PrivateSubnets:
    Description: The internal subnets.
    Type: List<AWS::EC2::Subnet::Id>

Metadata:
  AWS::CloudFormation::Interface:
    ParameterGroups:
    - Label:
        default: "Cluster Information"
      Parameters:
      - InfrastructureName
```

```
    - Label:
        default: "Network Configuration"
      Parameters:
      - VpcId
      - VpcCidr
      - PrivateSubnets
    ParameterLabels:
      InfrastructureName:
        default: "Infrastructure Name"
      VpcId:
        default: "VPC ID"
      VpcCidr:
        default: "VPC CIDR"
      PrivateSubnets:
        default: "Private Subnets"

Resources:
  MasterSecurityGroup:
    Type: AWS::EC2::SecurityGroup
    Properties:
      GroupDescription: Cluster Master Security Group
      SecurityGroupIngress:
      - IpProtocol: icmp
        FromPort: 0
        ToPort: 0
        CidrIp: !Ref VpcCidr
      - IpProtocol: tcp
        FromPort: 22
        ToPort: 22
        CidrIp: !Ref VpcCidr
      - IpProtocol: tcp
        ToPort: 6443
        FromPort: 6443
        CidrIp: !Ref VpcCidr
      - IpProtocol: tcp
        FromPort: 22623
        ToPort: 22623
        CidrIp: !Ref VpcCidr
      VpcId: !Ref VpcId

  WorkerSecurityGroup:
    Type: AWS::EC2::SecurityGroup
    Properties:
      GroupDescription: Cluster Worker Security Group
      SecurityGroupIngress:
      - IpProtocol: icmp
        FromPort: 0
        ToPort: 0
        CidrIp: !Ref VpcCidr
      - IpProtocol: tcp
        FromPort: 22
        ToPort: 22
        CidrIp: !Ref VpcCidr
      VpcId: !Ref VpcId

  MasterIngressEtcd:
```

```
    Type: AWS::EC2::SecurityGroupIngress
    Properties:
      GroupId: !GetAtt MasterSecurityGroup.GroupId
      SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId
      Description: etcd
      FromPort: 2379
      ToPort: 2380
      IpProtocol: tcp

  MasterIngressVxlan:
    Type: AWS::EC2::SecurityGroupIngress
    Properties:
      GroupId: !GetAtt MasterSecurityGroup.GroupId
      SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId
      Description: Vxlan packets
      FromPort: 4789
      ToPort: 4789
      IpProtocol: udp

  MasterIngressWorkerVxlan:
    Type: AWS::EC2::SecurityGroupIngress
    Properties:
      GroupId: !GetAtt MasterSecurityGroup.GroupId
      SourceSecurityGroupId: !GetAtt WorkerSecurityGroup.GroupId
      Description: Vxlan packets
      FromPort: 4789
      ToPort: 4789
      IpProtocol: udp

  MasterIngressGeneve:
    Type: AWS::EC2::SecurityGroupIngress
    Properties:
      GroupId: !GetAtt MasterSecurityGroup.GroupId
      SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId
      Description: Geneve packets
      FromPort: 6081
      ToPort: 6081
      IpProtocol: udp

  MasterIngressWorkerGeneve:
    Type: AWS::EC2::SecurityGroupIngress
    Properties:
      GroupId: !GetAtt MasterSecurityGroup.GroupId
      SourceSecurityGroupId: !GetAtt WorkerSecurityGroup.GroupId
      Description: Geneve packets
      FromPort: 6081
      ToPort: 6081
      IpProtocol: udp

  MasterIngressIpsecIke:
    Type: AWS::EC2::SecurityGroupIngress
    Properties:
      GroupId: !GetAtt MasterSecurityGroup.GroupId
      SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId
      Description: IPsec IKE packets
      FromPort: 500
```

```
    ToPort: 500
    IpProtocol: udp

MasterIngressIpsecNat:
  Type: AWS::EC2::SecurityGroupIngress
  Properties:
    GroupId: !GetAtt MasterSecurityGroup.GroupId
    SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId
    Description: IPsec NAT-T packets
    FromPort: 4500
    ToPort: 4500
    IpProtocol: udp

MasterIngressIpsecEsp:
  Type: AWS::EC2::SecurityGroupIngress
  Properties:
    GroupId: !GetAtt MasterSecurityGroup.GroupId
    SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId
    Description: IPsec ESP packets
    IpProtocol: 50

MasterIngressWorkerIpsecIke:
  Type: AWS::EC2::SecurityGroupIngress
  Properties:
    GroupId: !GetAtt MasterSecurityGroup.GroupId
    SourceSecurityGroupId: !GetAtt WorkerSecurityGroup.GroupId
    Description: IPsec IKE packets
    FromPort: 500
    ToPort: 500
    IpProtocol: udp

MasterIngressWorkerIpsecNat:
  Type: AWS::EC2::SecurityGroupIngress
  Properties:
    GroupId: !GetAtt MasterSecurityGroup.GroupId
    SourceSecurityGroupId: !GetAtt WorkerSecurityGroup.GroupId
    Description: IPsec NAT-T packets
    FromPort: 4500
    ToPort: 4500
    IpProtocol: udp

MasterIngressWorkerIpsecEsp:
  Type: AWS::EC2::SecurityGroupIngress
  Properties:
    GroupId: !GetAtt MasterSecurityGroup.GroupId
    SourceSecurityGroupId: !GetAtt WorkerSecurityGroup.GroupId
    Description: IPsec ESP packets
    IpProtocol: 50

MasterIngressInternal:
  Type: AWS::EC2::SecurityGroupIngress
  Properties:
    GroupId: !GetAtt MasterSecurityGroup.GroupId
    SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId
    Description: Internal cluster communication
    FromPort: 9000
```

```
      ToPort: 9999
      IpProtocol: tcp

  MasterIngressWorkerInternal:
    Type: AWS::EC2::SecurityGroupIngress
    Properties:
      GroupId: !GetAtt MasterSecurityGroup.GroupId
      SourceSecurityGroupId: !GetAtt WorkerSecurityGroup.GroupId
      Description: Internal cluster communication
      FromPort: 9000
      ToPort: 9999
      IpProtocol: tcp

  MasterIngressInternalUDP:
    Type: AWS::EC2::SecurityGroupIngress
    Properties:
      GroupId: !GetAtt MasterSecurityGroup.GroupId
      SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId
      Description: Internal cluster communication
      FromPort: 9000
      ToPort: 9999
      IpProtocol: udp

  MasterIngressWorkerInternalUDP:
    Type: AWS::EC2::SecurityGroupIngress
    Properties:
      GroupId: !GetAtt MasterSecurityGroup.GroupId
      SourceSecurityGroupId: !GetAtt WorkerSecurityGroup.GroupId
      Description: Internal cluster communication
      FromPort: 9000
      ToPort: 9999
      IpProtocol: udp

  MasterIngressKube:
    Type: AWS::EC2::SecurityGroupIngress
    Properties:
      GroupId: !GetAtt MasterSecurityGroup.GroupId
      SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId
      Description: Kubernetes kubelet, scheduler and controller manager
      FromPort: 10250
      ToPort: 10259
      IpProtocol: tcp

  MasterIngressWorkerKube:
    Type: AWS::EC2::SecurityGroupIngress
    Properties:
      GroupId: !GetAtt MasterSecurityGroup.GroupId
      SourceSecurityGroupId: !GetAtt WorkerSecurityGroup.GroupId
      Description: Kubernetes kubelet, scheduler and controller manager
      FromPort: 10250
      ToPort: 10259
      IpProtocol: tcp

  MasterIngressIngressServices:
    Type: AWS::EC2::SecurityGroupIngress
    Properties:
```

```
    GroupId: !GetAtt MasterSecurityGroup.GroupId
    SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId
    Description: Kubernetes ingress services
    FromPort: 30000
    ToPort: 32767
    IpProtocol: tcp

MasterIngressWorkerIngressServices:
  Type: AWS::EC2::SecurityGroupIngress
  Properties:
    GroupId: !GetAtt MasterSecurityGroup.GroupId
    SourceSecurityGroupId: !GetAtt WorkerSecurityGroup.GroupId
    Description: Kubernetes ingress services
    FromPort: 30000
    ToPort: 32767
    IpProtocol: tcp

MasterIngressIngressServicesUDP:
  Type: AWS::EC2::SecurityGroupIngress
  Properties:
    GroupId: !GetAtt MasterSecurityGroup.GroupId
    SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId
    Description: Kubernetes ingress services
    FromPort: 30000
    ToPort: 32767
    IpProtocol: udp

MasterIngressWorkerIngressServicesUDP:
  Type: AWS::EC2::SecurityGroupIngress
  Properties:
    GroupId: !GetAtt MasterSecurityGroup.GroupId
    SourceSecurityGroupId: !GetAtt WorkerSecurityGroup.GroupId
    Description: Kubernetes ingress services
    FromPort: 30000
    ToPort: 32767
    IpProtocol: udp

WorkerIngressVxlan:
  Type: AWS::EC2::SecurityGroupIngress
  Properties:
    GroupId: !GetAtt WorkerSecurityGroup.GroupId
    SourceSecurityGroupId: !GetAtt WorkerSecurityGroup.GroupId
    Description: Vxlan packets
    FromPort: 4789
    ToPort: 4789
    IpProtocol: udp

WorkerIngressMasterVxlan:
  Type: AWS::EC2::SecurityGroupIngress
  Properties:
    GroupId: !GetAtt WorkerSecurityGroup.GroupId
    SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId
    Description: Vxlan packets
    FromPort: 4789
    ToPort: 4789
    IpProtocol: udp
```

```
  WorkerIngressGeneve:
    Type: AWS::EC2::SecurityGroupIngress
    Properties:
      GroupId: !GetAtt WorkerSecurityGroup.GroupId
      SourceSecurityGroupId: !GetAtt WorkerSecurityGroup.GroupId
      Description: Geneve packets
      FromPort: 6081
      ToPort: 6081
      IpProtocol: udp

  WorkerIngressMasterGeneve:
    Type: AWS::EC2::SecurityGroupIngress
    Properties:
      GroupId: !GetAtt WorkerSecurityGroup.GroupId
      SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId
      Description: Geneve packets
      FromPort: 6081
      ToPort: 6081
      IpProtocol: udp

  WorkerIngressIpsecIke:
    Type: AWS::EC2::SecurityGroupIngress
    Properties:
      GroupId: !GetAtt WorkerSecurityGroup.GroupId
      SourceSecurityGroupId: !GetAtt WorkerSecurityGroup.GroupId
      Description: IPsec IKE packets
      FromPort: 500
      ToPort: 500
      IpProtocol: udp

  WorkerIngressIpsecNat:
    Type: AWS::EC2::SecurityGroupIngress
    Properties:
      GroupId: !GetAtt WorkerSecurityGroup.GroupId
      SourceSecurityGroupId: !GetAtt WorkerSecurityGroup.GroupId
      Description: IPsec NAT-T packets
      FromPort: 4500
      ToPort: 4500
      IpProtocol: udp

  WorkerIngressIpsecEsp:
    Type: AWS::EC2::SecurityGroupIngress
    Properties:
      GroupId: !GetAtt WorkerSecurityGroup.GroupId
      SourceSecurityGroupId: !GetAtt WorkerSecurityGroup.GroupId
      Description: IPsec ESP packets
      IpProtocol: 50

  WorkerIngressMasterIpsecIke:
    Type: AWS::EC2::SecurityGroupIngress
    Properties:
      GroupId: !GetAtt WorkerSecurityGroup.GroupId
      SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId
      Description: IPsec IKE packets
      FromPort: 500
```

```
    ToPort: 500
    IpProtocol: udp

  WorkerIngressMasterIpsecNat:
    Type: AWS::EC2::SecurityGroupIngress
    Properties:
      GroupId: !GetAtt WorkerSecurityGroup.GroupId
      SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId
      Description: IPsec NAT-T packets
      FromPort: 4500
      ToPort: 4500
      IpProtocol: udp

  WorkerIngressMasterIpsecEsp:
    Type: AWS::EC2::SecurityGroupIngress
    Properties:
      GroupId: !GetAtt WorkerSecurityGroup.GroupId
      SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId
      Description: IPsec ESP packets
      IpProtocol: 50

  WorkerIngressInternal:
    Type: AWS::EC2::SecurityGroupIngress
    Properties:
      GroupId: !GetAtt WorkerSecurityGroup.GroupId
      SourceSecurityGroupId: !GetAtt WorkerSecurityGroup.GroupId
      Description: Internal cluster communication
      FromPort: 9000
      ToPort: 9999
      IpProtocol: tcp

  WorkerIngressMasterInternal:
    Type: AWS::EC2::SecurityGroupIngress
    Properties:
      GroupId: !GetAtt WorkerSecurityGroup.GroupId
      SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId
      Description: Internal cluster communication
      FromPort: 9000
      ToPort: 9999
      IpProtocol: tcp

  WorkerIngressInternalUDP:
    Type: AWS::EC2::SecurityGroupIngress
    Properties:
      GroupId: !GetAtt WorkerSecurityGroup.GroupId
      SourceSecurityGroupId: !GetAtt WorkerSecurityGroup.GroupId
      Description: Internal cluster communication
      FromPort: 9000
      ToPort: 9999
      IpProtocol: udp

  WorkerIngressMasterInternalUDP:
    Type: AWS::EC2::SecurityGroupIngress
    Properties:
      GroupId: !GetAtt WorkerSecurityGroup.GroupId
      SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId
```

```
      Description: Internal cluster communication
      FromPort: 9000
      ToPort: 9999
      IpProtocol: udp

  WorkerIngressKube:
    Type: AWS::EC2::SecurityGroupIngress
    Properties:
      GroupId: !GetAtt WorkerSecurityGroup.GroupId
      SourceSecurityGroupId: !GetAtt WorkerSecurityGroup.GroupId
      Description: Kubernetes secure kubelet port
      FromPort: 10250
      ToPort: 10250
      IpProtocol: tcp

  WorkerIngressWorkerKube:
    Type: AWS::EC2::SecurityGroupIngress
    Properties:
      GroupId: !GetAtt WorkerSecurityGroup.GroupId
      SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId
      Description: Internal Kubernetes communication
      FromPort: 10250
      ToPort: 10250
      IpProtocol: tcp

  WorkerIngressIngressServices:
    Type: AWS::EC2::SecurityGroupIngress
    Properties:
      GroupId: !GetAtt WorkerSecurityGroup.GroupId
      SourceSecurityGroupId: !GetAtt WorkerSecurityGroup.GroupId
      Description: Kubernetes ingress services
      FromPort: 30000
      ToPort: 32767
      IpProtocol: tcp

  WorkerIngressMasterIngressServices:
    Type: AWS::EC2::SecurityGroupIngress
    Properties:
      GroupId: !GetAtt WorkerSecurityGroup.GroupId
      SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId
      Description: Kubernetes ingress services
      FromPort: 30000
      ToPort: 32767
      IpProtocol: tcp

  WorkerIngressIngressServicesUDP:
    Type: AWS::EC2::SecurityGroupIngress
    Properties:
      GroupId: !GetAtt WorkerSecurityGroup.GroupId
      SourceSecurityGroupId: !GetAtt WorkerSecurityGroup.GroupId
      Description: Kubernetes ingress services
      FromPort: 30000
      ToPort: 32767
      IpProtocol: udp

  WorkerIngressMasterIngressServicesUDP:
```

```
  Type: AWS::EC2::SecurityGroupIngress
  Properties:
    GroupId: !GetAtt WorkerSecurityGroup.GroupId
    SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId
    Description: Kubernetes ingress services
    FromPort: 30000
    ToPort: 32767
    IpProtocol: udp

MasterIamRole:
  Type: AWS::IAM::Role
  Properties:
    AssumeRolePolicyDocument:
      Version: "2012-10-17"
      Statement:
      - Effect: "Allow"
        Principal:
          Service:
          - "ec2.amazonaws.com"
        Action:
        - "sts:AssumeRole"
    Policies:
    - PolicyName: !Join ["-", [!Ref InfrastructureName, "master", "policy"]]
      PolicyDocument:
        Version: "2012-10-17"
        Statement:
        - Effect: "Allow"
          Action:
          - "ec2:AttachVolume"
          - "ec2:AuthorizeSecurityGroupIngress"
          - "ec2:CreateSecurityGroup"
          - "ec2:CreateTags"
          - "ec2:CreateVolume"
          - "ec2:DeleteSecurityGroup"
          - "ec2:DeleteVolume"
          - "ec2:Describe*"
          - "ec2:DetachVolume"
          - "ec2:ModifyInstanceAttribute"
          - "ec2:ModifyVolume"
          - "ec2:RevokeSecurityGroupIngress"
          - "elasticloadbalancing:AddTags"
          - "elasticloadbalancing:AttachLoadBalancerToSubnets"
          - "elasticloadbalancing:ApplySecurityGroupsToLoadBalancer"
          - "elasticloadbalancing:CreateListener"
          - "elasticloadbalancing:CreateLoadBalancer"
          - "elasticloadbalancing:CreateLoadBalancerPolicy"
          - "elasticloadbalancing:CreateLoadBalancerListeners"
          - "elasticloadbalancing:CreateTargetGroup"
          - "elasticloadbalancing:ConfigureHealthCheck"
          - "elasticloadbalancing:DeleteListener"
          - "elasticloadbalancing:DeleteLoadBalancer"
          - "elasticloadbalancing:DeleteLoadBalancerListeners"
          - "elasticloadbalancing:DeleteTargetGroup"
          - "elasticloadbalancing:DeregisterInstancesFromLoadBalancer"
          - "elasticloadbalancing:DeregisterTargets"
          - "elasticloadbalancing:Describe*"
```

```
            - "elasticloadbalancing:DetachLoadBalancerFromSubnets"
            - "elasticloadbalancing:ModifyListener"
            - "elasticloadbalancing:ModifyLoadBalancerAttributes"
            - "elasticloadbalancing:ModifyTargetGroup"
            - "elasticloadbalancing:ModifyTargetGroupAttributes"
            - "elasticloadbalancing:RegisterInstancesWithLoadBalancer"
            - "elasticloadbalancing:RegisterTargets"
            - "elasticloadbalancing:SetLoadBalancerPoliciesForBackendServer"
            - "elasticloadbalancing:SetLoadBalancerPoliciesOfListener"
            - "kms:DescribeKey"
            Resource: "*"

  MasterInstanceProfile:
    Type: "AWS::IAM::InstanceProfile"
    Properties:
      Roles:
      - Ref: "MasterIamRole"

  WorkerIamRole:
    Type: AWS::IAM::Role
    Properties:
      AssumeRolePolicyDocument:
        Version: "2012-10-17"
        Statement:
        - Effect: "Allow"
          Principal:
            Service:
            - "ec2.amazonaws.com"
          Action:
          - "sts:AssumeRole"
      Policies:
      - PolicyName: !Join ["-", [!Ref InfrastructureName, "worker", "policy"]]
        PolicyDocument:
          Version: "2012-10-17"
          Statement:
          - Effect: "Allow"
            Action:
            - "ec2:DescribeInstances"
            - "ec2:DescribeRegions"
            Resource: "*"

  WorkerInstanceProfile:
    Type: "AWS::IAM::InstanceProfile"
    Properties:
      Roles:
      - Ref: "WorkerIamRole"

Outputs:
  MasterSecurityGroupId:
    Description: Master Security Group ID
    Value: !GetAtt MasterSecurityGroup.GroupId

  WorkerSecurityGroupId:
    Description: Worker Security Group ID
    Value: !GetAtt WorkerSecurityGroup.GroupId
```

```
MasterInstanceProfile:
  Description: Master IAM Instance Profile
  Value: !Ref MasterInstanceProfile

WorkerInstanceProfile:
  Description: Worker IAM Instance Profile
  Value: !Ref WorkerInstanceProfile
```

5.14.12. Accessing RHCOS AMIs with stream metadata

In OpenShift Container Platform, *stream metadata* provides standardized metadata about RHCOS in the JSON format and injects the metadata into the cluster. Stream metadata is a stable format that supports multiple architectures and is intended to be self-documenting for maintaining automation.

You can use the **coreos print-stream-json** sub-command of **openshift-install** to access information about the boot images in the stream metadata format. This command provides a method for printing stream metadata in a scriptable, machine-readable format.

For user-provisioned installations, the **openshift-install** binary contains references to the version of RHCOS boot images that are tested for use with OpenShift Container Platform, such as the AWS AMI.

Procedure

To parse the stream metadata, use one of the following methods:

- From a Go program, use the official **stream-metadata-go** library at https://github.com/coreos/stream-metadata-go. You can also view example code in the library.
- From another programming language, such as Python or Ruby, use the JSON library of your preferred programming language.
- From a command-line utility that handles JSON data, such as **jq**:
  - Print the current **x86_64** or **aarch64** AMI for an AWS region, such as **us-west-1**:

    For x86_64

    ```
    $ openshift-install coreos print-stream-json | jq -r
    '.architectures.x86_64.images.aws.regions["us-west-1"].image'
    ```

    Example output

    ```
    ami-0d3e625f84626bbda
    ```

    For aarch64

    ```
    $ openshift-install coreos print-stream-json | jq -r
    '.architectures.aarch64.images.aws.regions["us-west-1"].image'
    ```

    Example output

    ```
    ami-0af1d3b7fa5be2131
    ```

The output of this command is the AWS AMI ID for your designated architecture and the **us-west-1** region. The AMI must belong to the same region as the cluster.

5.14.13. RHCOS AMIs for the AWS infrastructure

Red Hat provides Red Hat Enterprise Linux CoreOS (RHCOS) AMIs that are valid for the various AWS regions and instance architectures that you can manually specify for your OpenShift Container Platform nodes.

NOTE

By importing your own AMI, you can also install to regions that do not have a published RHCOS AMI.

Table 5.52. x86_64 RHCOS AMIs

AWS zone	AWS AMI
af-south-1	**ami-0067394b051d857f9**
ap-east-1	**ami-057f593cc29fd3e08**
ap-northeast-1	**ami-0f5bfc3e39711a7d8**
ap-northeast-2	**ami-07b8f6b801b49a0b7**
ap-northeast-3	**ami-0677b0ba9d47e5e3a**
ap-south-1	**ami-0755c7732de0421e7**
ap-southeast-1	**ami-07b2f18a01b8ddce4**
ap-southeast-2	**ami-075b1af2bc583944b**
ap-southeast-3	**ami-0b5a81f57762da2f4**
ca-central-1	**ami-0fda98e014e64d6c4**
eu-central-1	**ami-0ba6fa5b3d81c5d56**
eu-north-1	**ami-08aed4be0d4d11b0c**
eu-south-1	**ami-0349bc626dd021c7c**
eu-west-1	**ami-0706a49df2a8357b6**
eu-west-2	**ami-0681b7397b0ec9691**

AWS zone	AWS AMI
eu-west-3	ami-0919c4668782f35da
me-south-1	ami-07ef03ebf19799060
sa-east-1	ami-046a4e6f57aea3234
us-east-1	ami-0722eb0819717090f
us-east-2	ami-026e5701f495c94a2
us-gov-east-1	ami-016dce87c45add851
us-gov-west-1	ami-0c5bb1f0b393638a0
us-west-1	ami-021ef831672014a17
us-west-2	ami-0bba4636ff1b1dc1c

Table 5.53. aarch64 RHCOS AMIs

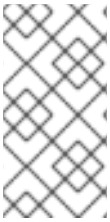
AWS zone	AWS AMI
ap-east-1	ami-083382a51b31f6bd1
ap-northeast-1	ami-09b84fda1b7171183
ap-northeast-2	ami-06404fbe4209e9557
ap-south-1	ami-0b9655b3c7c3525ba
ap-southeast-1	ami-0a9b453d016e3dfde
ap-southeast-2	ami-0e7af060f6e927702
ca-central-1	ami-0c8293928c44b6bbd
eu-central-1	ami-08a950d054a165e21
eu-north-1	ami-020dd619ad4f379dd
eu-south-1	ami-0b915ff416b9aad24
eu-west-1	ami-034df7689a87ce826

AWS zone	AWS AMI
eu-west-2	**ami-02bf81e08b4b2f1ef**
eu-west-3	**ami-03878de77169a8599**
me-south-1	**ami-034b27bd530bac050**
sa-east-1	**ami-06ab90bd7daf4dd8b**
us-east-1	**ami-00d3196d06bc2a924**
us-east-2	**ami-028a3d23312630036**
us-west-1	**ami-05356b8fece665cf1**
us-west-2	**ami-0e6473997df31eb0f**

5.14.14. Creating the bootstrap node in AWS

You must create the bootstrap node in Amazon Web Services (AWS) to use during OpenShift Container Platform cluster initialization. You do this by:

- Providing a location to serve the **bootstrap.ign** Ignition config file to your cluster. This file is located in your installation directory. The provided CloudFormation Template assumes that the Ignition config files for your cluster are served from an S3 bucket. If you choose to serve the files from another location, you must modify the templates.
- Using the provided CloudFormation template and a custom parameter file to create a stack of AWS resources. The stack represents the bootstrap node that your OpenShift Container Platform installation requires.



NOTE

If you do not use the provided CloudFormation template to create your bootstrap node, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

Prerequisites

- You configured an AWS account.
- You added your AWS keys and region to your local AWS profile by running **aws configure**.
- You generated the Ignition config files for your cluster.
- You created and configured a VPC and associated subnets in AWS.
- You created and configured DNS, load balancers, and listeners in AWS.

- You created the security groups and roles required for your cluster in AWS.

Procedure

1. Create the bucket by running the following command:

```
$ aws s3 mb s3://<cluster-name>-infra 1
```

1 **<cluster-name>-infra** is the bucket name. When creating the **install-config.yaml** file, replace **<cluster-name>** with the name specified for the cluster.

You must use a presigned URL for your S3 bucket, instead of the **s3://** schema, if you are:

- Deploying to a region that has endpoints that differ from the AWS SDK.
- Deploying a proxy.
- Providing your own custom endpoints.

2. Upload the **bootstrap.ign** Ignition config file to the bucket by running the following command:

```
$ aws s3 cp <installation_directory>/bootstrap.ign s3://<cluster-name>-infra/bootstrap.ign 1
```

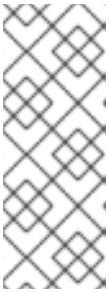
1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

3. Verify that the file uploaded by running the following command:

```
$ aws s3 ls s3://<cluster-name>-infra/
```

Example output

```
2019-04-03 16:15:16     314878 bootstrap.ign
```



NOTE

The bootstrap Ignition config file does contain secrets, like X.509 keys. The following steps provide basic security for the S3 bucket. To provide additional security, you can enable an S3 bucket policy to allow only certain users, such as the OpenShift IAM user, to access objects that the bucket contains. You can avoid S3 entirely and serve your bootstrap Ignition config file from any address that the bootstrap machine can reach.

4. Create a JSON file that contains the parameter values that the template requires:

```
[
  {
    "ParameterKey": "InfrastructureName", 1
    "ParameterValue": "mycluster-<random_string>" 2
  },
  {
```

```
  "ParameterKey": "RhcosAmi", 3
  "ParameterValue": "ami-<random_string>" 4
 },
 {
  "ParameterKey": "AllowedBootstrapSshCidr", 5
  "ParameterValue": "0.0.0.0/0" 6
 },
 {
  "ParameterKey": "PublicSubnet", 7
  "ParameterValue": "subnet-<random_string>" 8
 },
 {
  "ParameterKey": "MasterSecurityGroupId", 9
  "ParameterValue": "sg-<random_string>" 10
 },
 {
  "ParameterKey": "VpcId", 11
  "ParameterValue": "vpc-<random_string>" 12
 },
 {
  "ParameterKey": "BootstrapIgnitionLocation", 13
  "ParameterValue": "s3://<bucket_name>/bootstrap.ign" 14
 },
 {
  "ParameterKey": "AutoRegisterELB", 15
  "ParameterValue": "yes" 16
 },
 {
  "ParameterKey": "RegisterNlbIpTargetsLambdaArn", 17
  "ParameterValue": "arn:aws:lambda:<region>:<account_number>:function:
<dns_stack_name>-RegisterNlbIpTargets-<random_string>" 18
 },
 {
  "ParameterKey": "ExternalApiTargetGroupArn", 19
  "ParameterValue": "arn:aws:elasticloadbalancing:<region>:
<account_number>:targetgroup/<dns_stack_name>-Exter-<random_string>" 20
 },
 {
  "ParameterKey": "InternalApiTargetGroupArn", 21
  "ParameterValue": "arn:aws:elasticloadbalancing:<region>:
<account_number>:targetgroup/<dns_stack_name>-Inter-<random_string>" 22
 },
 {
  "ParameterKey": "InternalServiceTargetGroupArn", 23
  "ParameterValue": "arn:aws:elasticloadbalancing:<region>:
<account_number>:targetgroup/<dns_stack_name>-Inter-<random_string>" 24
 }
]
```

1 The name for your cluster infrastructure that is encoded in your Ignition config files for the cluster.

2

Specify the infrastructure name that you extracted from the Ignition config file metadata, which has the format **<cluster-name>-<random-string>**.

3 Current Red Hat Enterprise Linux CoreOS (RHCOS) AMI to use for the bootstrap node based on your selected architecture.

4 Specify a valid **AWS::EC2::Image::Id** value.

5 CIDR block to allow SSH access to the bootstrap node.

6 Specify a CIDR block in the format **x.x.x.x/16-24**.

7 The public subnet that is associated with your VPC to launch the bootstrap node into.

8 Specify the **PublicSubnetIds** value from the output of the CloudFormation template for the VPC.

9 The master security group ID (for registering temporary rules)

10 Specify the **MasterSecurityGroupId** value from the output of the CloudFormation template for the security group and roles.

11 The VPC created resources will belong to.

12 Specify the **VpcId** value from the output of the CloudFormation template for the VPC.

13 Location to fetch bootstrap Ignition config file from.

14 Specify the S3 bucket and file name in the form **s3://<bucket_name>/bootstrap.ign**.

15 Whether or not to register a network load balancer (NLB).

16 Specify **yes** or **no**. If you specify **yes**, you must provide a Lambda Amazon Resource Name (ARN) value.

17 The ARN for NLB IP target registration lambda group.

18 Specify the **RegisterNlbIpTargetsLambda** value from the output of the CloudFormation template for DNS and load balancing. Use **arn:aws-us-gov** if deploying the cluster to an AWS GovCloud region.

19 The ARN for external API load balancer target group.

20 Specify the **ExternalApiTargetGroupArn** value from the output of the CloudFormation template for DNS and load balancing. Use **arn:aws-us-gov** if deploying the cluster to an AWS GovCloud region.

21 The ARN for internal API load balancer target group.

22 Specify the **InternalApiTargetGroupArn** value from the output of the CloudFormation template for DNS and load balancing. Use **arn:aws-us-gov** if deploying the cluster to an AWS GovCloud region.

23 The ARN for internal service load balancer target group.

24 Specify the **InternalServiceTargetGroupArn** value from the output of the CloudFormation template for DNS and load balancing. Use **arn:aws-us-gov** if deploying the cluster to an AWS GovCloud region.

5. Copy the template from the **CloudFormation template for the bootstrap machine** section of this topic and save it as a YAML file on your computer. This template describes the bootstrap machine that your cluster requires.

6. Optional: If you are deploying the cluster with a proxy, you must update the ignition in the template to add the **ignition.config.proxy** fields. Additionally, If you have added the Amazon EC2, Elastic Load Balancing, and S3 VPC endpoints to your VPC, you must add these endpoints to the **noProxy** field.

7. Launch the CloudFormation template to create a stack of AWS resources that represent the bootstrap node:

IMPORTANT

You must enter the command on a single line.

```
$ aws cloudformation create-stack --stack-name <name> 1
    --template-body file://<template>.yaml 2
    --parameters file://<parameters>.json 3
    --capabilities CAPABILITY_NAMED_IAM 4
```

1 **<name>** is the name for the CloudFormation stack, such as **cluster-bootstrap**. You need the name of this stack if you remove the cluster.

2 **<template>** is the relative path to and name of the CloudFormation template YAML file that you saved.

3 **<parameters>** is the relative path to and name of the CloudFormation parameters JSON file.

4 You must explicitly declare the **CAPABILITY_NAMED_IAM** capability because the provided template creates some **AWS::IAM::Role** and **AWS::IAM::InstanceProfile** resources.

Example output

```
arn:aws:cloudformation:us-east-1:269333783861:stack/cluster-bootstrap/12944486-2add-11eb-9dee-12dace8e3a83
```

8. Confirm that the template components exist:

```
$ aws cloudformation describe-stacks --stack-name <name>
```

After the **StackStatus** displays **CREATE_COMPLETE**, the output displays values for the following parameters. You must provide these parameter values to the other CloudFormation templates that you run to create your cluster:

Bootstrap InstanceId	The bootstrap Instance ID.

Bootstrap PublicIp	The bootstrap node public IP address.
Bootstrap PrivateIp	The bootstrap node private IP address.

5.14.14.1. CloudFormation template for the bootstrap machine

You can use the following CloudFormation template to deploy the bootstrap machine that you need for your OpenShift Container Platform cluster.

Example 5.68. CloudFormation template for the bootstrap machine

```
AWSTemplateFormatVersion: 2010-09-09
Description: Template for OpenShift Cluster Bootstrap (EC2 Instance, Security Groups and IAM)

Parameters:
  InfrastructureName:
    AllowedPattern: ^([a-zA-Z][a-zA-Z0-9\-]{0,26})$
    MaxLength: 27
    MinLength: 1
    ConstraintDescription: Infrastructure name must be alphanumeric, start with a letter, and have a
maximum of 27 characters.
    Description: A short, unique cluster ID used to tag cloud resources and identify items owned or
used by the cluster.
    Type: String
  RhcosAmi:
    Description: Current Red Hat Enterprise Linux CoreOS AMI to use for bootstrap.
    Type: AWS::EC2::Image::Id
  AllowedBootstrapSshCidr:
    AllowedPattern: ^(([0-9]|[1-9][0-9]|1[0-9]{2}|2[0-4][0-9]|25[0-5])\.){3}([0-9]|[1-9][0-9]|1[0-9]{2}|2[0-
4][0-9]|25[0-5])(\/([0-9]|1[0-9]|2[0-9]|3[0-2]))$
    ConstraintDescription: CIDR block parameter must be in the form x.x.x.x/0-32.
    Default: 0.0.0.0/0
    Description: CIDR block to allow SSH access to the bootstrap node.
    Type: String
  PublicSubnet:
    Description: The public subnet to launch the bootstrap node into.
    Type: AWS::EC2::Subnet::Id
  MasterSecurityGroupId:
    Description: The master security group ID for registering temporary rules.
    Type: AWS::EC2::SecurityGroup::Id
  VpcId:
    Description: The VPC-scoped resources will belong to this VPC.
    Type: AWS::EC2::VPC::Id
  BootstrapIgnitionLocation:
    Default: s3://my-s3-bucket/bootstrap.ign
    Description: Ignition config file location.
    Type: String
  AutoRegisterELB:
    Default: "yes"
    AllowedValues:
    - "yes"
    - "no"
```

```
    Description: Do you want to invoke NLB registration, which requires a Lambda ARN parameter?
    Type: String
  RegisterNlbIpTargetsLambdaArn:
    Description: ARN for NLB IP target registration lambda.
    Type: String
  ExternalApiTargetGroupArn:
    Description: ARN for external API load balancer target group.
    Type: String
  InternalApiTargetGroupArn:
    Description: ARN for internal API load balancer target group.
    Type: String
  InternalServiceTargetGroupArn:
    Description: ARN for internal service load balancer target group.
    Type: String
  BootstrapInstanceType:
    Description: Instance type for the bootstrap EC2 instance
    Default: "i3.large"
    Type: String

Metadata:
  AWS::CloudFormation::Interface:
    ParameterGroups:
    - Label:
        default: "Cluster Information"
      Parameters:
      - InfrastructureName
    - Label:
        default: "Host Information"
      Parameters:
      - RhcosAmi
      - BootstrapIgnitionLocation
      - MasterSecurityGroupId
    - Label:
        default: "Network Configuration"
      Parameters:
      - VpcId
      - AllowedBootstrapSshCidr
      - PublicSubnet
    - Label:
        default: "Load Balancer Automation"
      Parameters:
      - AutoRegisterELB
      - RegisterNlbIpTargetsLambdaArn
      - ExternalApiTargetGroupArn
      - InternalApiTargetGroupArn
      - InternalServiceTargetGroupArn
    ParameterLabels:
      InfrastructureName:
        default: "Infrastructure Name"
      VpcId:
        default: "VPC ID"
      AllowedBootstrapSshCidr:
        default: "Allowed SSH Source"
      PublicSubnet:
        default: "Public Subnet"
      RhcosAmi:
```

```
      default: "Red Hat Enterprise Linux CoreOS AMI ID"
    BootstrapIgnitionLocation:
      default: "Bootstrap Ignition Source"
    MasterSecurityGroupId:
      default: "Master Security Group ID"
    AutoRegisterELB:
      default: "Use Provided ELB Automation"

Conditions:
  DoRegistration: !Equals ["yes", !Ref AutoRegisterELB]

Resources:
  BootstrapIamRole:
    Type: AWS::IAM::Role
    Properties:
      AssumeRolePolicyDocument:
        Version: "2012-10-17"
        Statement:
        - Effect: "Allow"
          Principal:
            Service:
            - "ec2.amazonaws.com"
          Action:
          - "sts:AssumeRole"
      Path: "/"
      Policies:
      - PolicyName: !Join ["-", [!Ref InfrastructureName, "bootstrap", "policy"]]
        PolicyDocument:
          Version: "2012-10-17"
          Statement:
          - Effect: "Allow"
            Action: "ec2:Describe*"
            Resource: "*"
          - Effect: "Allow"
            Action: "ec2:AttachVolume"
            Resource: "*"
          - Effect: "Allow"
            Action: "ec2:DetachVolume"
            Resource: "*"
          - Effect: "Allow"
            Action: "s3:GetObject"
            Resource: "*"

  BootstrapInstanceProfile:
    Type: "AWS::IAM::InstanceProfile"
    Properties:
      Path: "/"
      Roles:
      - Ref: "BootstrapIamRole"

  BootstrapSecurityGroup:
    Type: AWS::EC2::SecurityGroup
    Properties:
      GroupDescription: Cluster Bootstrap Security Group
      SecurityGroupIngress:
      - IpProtocol: tcp
```

```
        FromPort: 22
        ToPort: 22
        CidrIp: !Ref AllowedBootstrapSshCidr
      - IpProtocol: tcp
        ToPort: 19531
        FromPort: 19531
        CidrIp: 0.0.0.0/0
      VpcId: !Ref VpcId

  BootstrapInstance:
    Type: AWS::EC2::Instance
    Properties:
      ImageId: !Ref RhcosAmi
      IamInstanceProfile: !Ref BootstrapInstanceProfile
      InstanceType: !Ref BootstrapInstanceType
      NetworkInterfaces:
      - AssociatePublicIpAddress: "true"
        DeviceIndex: "0"
        GroupSet:
        - !Ref "BootstrapSecurityGroup"
        - !Ref "MasterSecurityGroupId"
        SubnetId: !Ref "PublicSubnet"
      UserData:
        Fn::Base64: !Sub
        - '{"ignition":{"config":{"replace":{"source":"${S3Loc}"}},"version":"3.1.0"}}'
        - {
          S3Loc: !Ref BootstrapIgnitionLocation
        }

  RegisterBootstrapApiTarget:
    Condition: DoRegistration
    Type: Custom::NLBRegister
    Properties:
      ServiceToken: !Ref RegisterNlbIpTargetsLambdaArn
      TargetArn: !Ref ExternalApiTargetGroupArn
      TargetIp: !GetAtt BootstrapInstance.PrivateIp

  RegisterBootstrapInternalApiTarget:
    Condition: DoRegistration
    Type: Custom::NLBRegister
    Properties:
      ServiceToken: !Ref RegisterNlbIpTargetsLambdaArn
      TargetArn: !Ref InternalApiTargetGroupArn
      TargetIp: !GetAtt BootstrapInstance.PrivateIp

  RegisterBootstrapInternalServiceTarget:
    Condition: DoRegistration
    Type: Custom::NLBRegister
    Properties:
      ServiceToken: !Ref RegisterNlbIpTargetsLambdaArn
      TargetArn: !Ref InternalServiceTargetGroupArn
      TargetIp: !GetAtt BootstrapInstance.PrivateIp

Outputs:
  BootstrapInstanceId:
    Description: Bootstrap Instance ID.
```

```
    Value: !Ref BootstrapInstance

BootstrapPublicIp:
  Description: The bootstrap node public IP address.
  Value: !GetAtt BootstrapInstance.PublicIp

BootstrapPrivateIp:
  Description: The bootstrap node private IP address.
  Value: !GetAtt BootstrapInstance.PrivateIp
```

Additional resources

- See RHCOS AMIs for the AWS infrastructure for details about the Red Hat Enterprise Linux CoreOS (RHCOS) AMIs for the AWS zones.

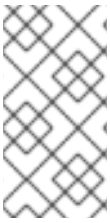
5.14.15. Creating the control plane machines in AWS

You must create the control plane machines in Amazon Web Services (AWS) that your cluster will use.

You can use the provided CloudFormation template and a custom parameter file to create a stack of AWS resources that represent the control plane nodes.

IMPORTANT

The CloudFormation template creates a stack that represents three control plane nodes.



NOTE

If you do not use the provided CloudFormation template to create your control plane nodes, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

Prerequisites

- You configured an AWS account.
- You added your AWS keys and region to your local AWS profile by running **aws configure**.
- You generated the Ignition config files for your cluster.
- You created and configured a VPC and associated subnets in AWS.
- You created and configured DNS, load balancers, and listeners in AWS.
- You created the security groups and roles required for your cluster in AWS.
- You created the bootstrap machine.

Procedure

1. Create a JSON file that contains the parameter values that the template requires:

```
[
  {
    "ParameterKey": "InfrastructureName", (1)
    "ParameterValue": "mycluster-<random_string>" (2)
  },
  {
    "ParameterKey": "RhcosAmi", (3)
    "ParameterValue": "ami-<random_string>" (4)
  },
  {
    "ParameterKey": "AutoRegisterDNS", (5)
    "ParameterValue": "yes" (6)
  },
  {
    "ParameterKey": "PrivateHostedZoneId", (7)
    "ParameterValue": "<random_string>" (8)
  },
  {
    "ParameterKey": "PrivateHostedZoneName", (9)
    "ParameterValue": "mycluster.example.com" (10)
  },
  {
    "ParameterKey": "Master0Subnet", (11)
    "ParameterValue": "subnet-<random_string>" (12)
  },
  {
    "ParameterKey": "Master1Subnet", (13)
    "ParameterValue": "subnet-<random_string>" (14)
  },
  {
    "ParameterKey": "Master2Subnet", (15)
    "ParameterValue": "subnet-<random_string>" (16)
  },
  {
    "ParameterKey": "MasterSecurityGroupId", (17)
    "ParameterValue": "sg-<random_string>" (18)
  },
  {
    "ParameterKey": "IgnitionLocation", (19)
    "ParameterValue": "https://api-int.<cluster_name>.<domain_name>:22623/config/master"
(20)
  },
  {
    "ParameterKey": "CertificateAuthorities", (21)
    "ParameterValue": "data:text/plain;charset=utf-8;base64,ABC...xYz==" (22)
  },
  {
    "ParameterKey": "MasterInstanceProfileName", (23)
    "ParameterValue": "<roles_stack>-MasterInstanceProfile-<random_string>" (24)
  },
  {
    "ParameterKey": "MasterInstanceType", (25)
```

```
    "ParameterValue": "" 26
  },
  {
    "ParameterKey": "AutoRegisterELB", 27
    "ParameterValue": "yes" 28
  },
  {
    "ParameterKey": "RegisterNlbIpTargetsLambdaArn", 29
    "ParameterValue": "arn:aws:lambda:<region>:<account_number>:function:
<dns_stack_name>-RegisterNlbIpTargets-<random_string>" 30
  },
  {
    "ParameterKey": "ExternalApiTargetGroupArn", 31
    "ParameterValue": "arn:aws:elasticloadbalancing:<region>:
<account_number>:targetgroup/<dns_stack_name>-Exter-<random_string>" 32
  },
  {
    "ParameterKey": "InternalApiTargetGroupArn", 33
    "ParameterValue": "arn:aws:elasticloadbalancing:<region>:
<account_number>:targetgroup/<dns_stack_name>-Inter-<random_string>" 34
  },
  {
    "ParameterKey": "InternalServiceTargetGroupArn", 35
    "ParameterValue": "arn:aws:elasticloadbalancing:<region>:
<account_number>:targetgroup/<dns_stack_name>-Inter-<random_string>" 36
  }
]
```

1. The name for your cluster infrastructure that is encoded in your Ignition config files for the cluster.
2. Specify the infrastructure name that you extracted from the Ignition config file metadata, which has the format **<cluster-name>-<random-string>**.
3. Current Red Hat Enterprise Linux CoreOS (RHCOS) AMI to use for the control plane machines based on your selected architecture.
4. Specify an **AWS::EC2::Image::Id** value.
5. Whether or not to perform DNS etcd registration.
6. Specify **yes** or **no**. If you specify **yes**, you must provide hosted zone information.
7. The Route 53 private zone ID to register the etcd targets with.
8. Specify the **PrivateHostedZoneId** value from the output of the CloudFormation template for DNS and load balancing.
9. The Route 53 zone to register the targets with.
10. Specify **<cluster_name>.<domain_name>** where **<domain_name>** is the Route 53 base domain that you used when you generated **install-config.yaml** file for the cluster. Do not include the trailing period (.) that is displayed in the AWS console.

11 13 15 A subnet, preferably private, to launch the control plane machines on.

12 14 16 Specify a subnet from the **PrivateSubnets** value from the output of the CloudFormation template for DNS and load balancing.

17 The master security group ID to associate with control plane nodes.

18 Specify the **MasterSecurityGroupId** value from the output of the CloudFormation template for the security group and roles.

19 The location to fetch control plane Ignition config file from.

20 Specify the generated Ignition config file location, **https://api-int.<cluster_name>.<domain_name>:22623/config/master**.

21 The base64 encoded certificate authority string to use.

22 Specify the value from the **master.ign** file that is in the installation directory. This value is the long string with the format **data:text/plain;charset=utf-8;base64,ABC...xYz==**.

23 The IAM profile to associate with control plane nodes.

24 Specify the **MasterInstanceProfile** parameter value from the output of the CloudFormation template for the security group and roles.

25 The type of AWS instance to use for the control plane machines based on your selected architecture.

26 The instance type value corresponds to the minimum resource requirements for control plane machines. For example **m6i.xlarge** is a type for AMD64. and **m6g.xlarge** is a type for ARM64.

27 Whether or not to register a network load balancer (NLB).

28 Specify **yes** or **no**. If you specify **yes**, you must provide a Lambda Amazon Resource Name (ARN) value.

29 The ARN for NLB IP target registration lambda group.

30 Specify the **RegisterNlbIpTargetsLambda** value from the output of the CloudFormation template for DNS and load balancing. Use **arn:aws-us-gov** if deploying the cluster to an AWS GovCloud region.

31 The ARN for external API load balancer target group.

32 Specify the **ExternalApiTargetGroupArn** value from the output of the CloudFormation template for DNS and load balancing. Use **arn:aws-us-gov** if deploying the cluster to an AWS GovCloud region.

33 The ARN for internal API load balancer target group.

34 Specify the **InternalApiTargetGroupArn** value from the output of the CloudFormation template for DNS and load balancing. Use **arn:aws-us-gov** if deploying the cluster to an AWS GovCloud region.

35 The ARN for internal service load balancer target group.

36 Specify the **InternalServiceTargetGroupArn** value from the output of the CloudFormation template for DNS and load balancing. Use **arn:aws-us-gov** if deploying the cluster to an AWS GovCloud region.

2. Copy the template from the **CloudFormation template for control plane machines**section of this topic and save it as a YAML file on your computer. This template describes the control plane machines that your cluster requires.

3. If you specified an **m5** instance type as the value for **MasterInstanceType**, add that instance type to the **MasterInstanceType.AllowedValues** parameter in the CloudFormation template.

4. Launch the CloudFormation template to create a stack of AWS resources that represent the control plane nodes:

IMPORTANT

You must enter the command on a single line.

```
$ aws cloudformation create-stack --stack-name <name> 1
    --template-body file://<template>.yaml 2
    --parameters file://<parameters>.json 3
```

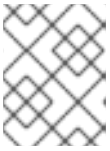
1 **<name>** is the name for the CloudFormation stack, such as **cluster-control-plane**. You need the name of this stack if you remove the cluster.

2 **<template>** is the relative path to and name of the CloudFormation template YAML file that you saved.

3 **<parameters>** is the relative path to and name of the CloudFormation parameters JSON file.

Example output

```
arn:aws:cloudformation:us-east-1:269333783861:stack/cluster-control-plane/21c7e2b0-2ee2-11eb-c6f6-0aa34627df4b
```



NOTE

The CloudFormation template creates a stack that represents three control plane nodes.

5. Confirm that the template components exist:

```
$ aws cloudformation describe-stacks --stack-name <name>
```

5.14.15.1. CloudFormation template for control plane machines

You can use the following CloudFormation template to deploy the control plane machines that you need for your OpenShift Container Platform cluster.

Example 5.69. CloudFormation template for control plane machines

```
AWSTemplateFormatVersion: 2010-09-09
Description: Template for OpenShift Cluster Node Launch (EC2 master instances)
```

```
Parameters:
  InfrastructureName:
    AllowedPattern: ^([a-zA-Z][a-zA-Z0-9\-]{0,26})$
    MaxLength: 27
    MinLength: 1
    ConstraintDescription: Infrastructure name must be alphanumeric, start with a letter, and have a
maximum of 27 characters.
    Description: A short, unique cluster ID used to tag nodes for the kubelet cloud provider.
    Type: String
  RhcosAmi:
    Description: Current Red Hat Enterprise Linux CoreOS AMI to use for bootstrap.
    Type: AWS::EC2::Image::Id
  AutoRegisterDNS:
    Default: ""
    Description: unused
    Type: String
  PrivateHostedZoneId:
    Default: ""
    Description: unused
    Type: String
  PrivateHostedZoneName:
    Default: ""
    Description: unused
    Type: String
  Master0Subnet:
    Description: The subnets, recommend private, to launch the master nodes into.
    Type: AWS::EC2::Subnet::Id
  Master1Subnet:
    Description: The subnets, recommend private, to launch the master nodes into.
    Type: AWS::EC2::Subnet::Id
  Master2Subnet:
    Description: The subnets, recommend private, to launch the master nodes into.
    Type: AWS::EC2::Subnet::Id
  MasterSecurityGroupId:
    Description: The master security group ID to associate with master nodes.
    Type: AWS::EC2::SecurityGroup::Id
  IgnitionLocation:
    Default: https://api-int.$CLUSTER_NAME.$DOMAIN:22623/config/master
    Description: Ignition config file location.
    Type: String
  CertificateAuthorities:
    Default: data:text/plain;charset=utf-8;base64,ABC...xYz==
    Description: Base64 encoded certificate authority string to use.
    Type: String
  MasterInstanceProfileName:
    Description: IAM profile to associate with master nodes.
    Type: String
  MasterInstanceType:
    Default: m5.xlarge
    Type: String

  AutoRegisterELB:
    Default: "yes"
    AllowedValues:
    - "yes"
    - "no"
```

```
    Description: Do you want to invoke NLB registration, which requires a Lambda ARN parameter?
    Type: String
  RegisterNlbIpTargetsLambdaArn:
    Description: ARN for NLB IP target registration lambda. Supply the value from the cluster
infrastructure or select "no" for AutoRegisterELB.
    Type: String
  ExternalApiTargetGroupArn:
    Description: ARN for external API load balancer target group. Supply the value from the cluster
infrastructure or select "no" for AutoRegisterELB.
    Type: String
  InternalApiTargetGroupArn:
    Description: ARN for internal API load balancer target group. Supply the value from the cluster
infrastructure or select "no" for AutoRegisterELB.
    Type: String
  InternalServiceTargetGroupArn:
    Description: ARN for internal service load balancer target group. Supply the value from the
cluster infrastructure or select "no" for AutoRegisterELB.
    Type: String

Metadata:
  AWS::CloudFormation::Interface:
    ParameterGroups:
    - Label:
        default: "Cluster Information"
      Parameters:
      - InfrastructureName
    - Label:
        default: "Host Information"
      Parameters:
      - MasterInstanceType
      - RhcosAmi
      - IgnitionLocation
      - CertificateAuthorities
      - MasterSecurityGroupId
      - MasterInstanceProfileName
    - Label:
        default: "Network Configuration"
      Parameters:
      - VpcId
      - AllowedBootstrapSshCidr
      - Master0Subnet
      - Master1Subnet
      - Master2Subnet
    - Label:
        default: "Load Balancer Automation"
      Parameters:
      - AutoRegisterELB
      - RegisterNlbIpTargetsLambdaArn
      - ExternalApiTargetGroupArn
      - InternalApiTargetGroupArn
      - InternalServiceTargetGroupArn
    ParameterLabels:
      InfrastructureName:
        default: "Infrastructure Name"
      VpcId:
        default: "VPC ID"
```

```
      Master0Subnet:
        default: "Master-0 Subnet"
      Master1Subnet:
        default: "Master-1 Subnet"
      Master2Subnet:
        default: "Master-2 Subnet"
      MasterInstanceType:
        default: "Master Instance Type"
      MasterInstanceProfileName:
        default: "Master Instance Profile Name"
      RhcosAmi:
        default: "Red Hat Enterprise Linux CoreOS AMI ID"
      BootstrapIgnitionLocation:
        default: "Master Ignition Source"
      CertificateAuthorities:
        default: "Ignition CA String"
      MasterSecurityGroupId:
        default: "Master Security Group ID"
      AutoRegisterELB:
        default: "Use Provided ELB Automation"

Conditions:
  DoRegistration: !Equals ["yes", !Ref AutoRegisterELB]

Resources:
  Master0:
    Type: AWS::EC2::Instance
    Properties:
      ImageId: !Ref RhcosAmi
      BlockDeviceMappings:
      - DeviceName: /dev/xvda
        Ebs:
          VolumeSize: "120"
          VolumeType: "gp2"
      IamInstanceProfile: !Ref MasterInstanceProfileName
      InstanceType: !Ref MasterInstanceType
      NetworkInterfaces:
      - AssociatePublicIpAddress: "false"
        DeviceIndex: "0"
        GroupSet:
        - !Ref "MasterSecurityGroupId"
        SubnetId: !Ref "Master0Subnet"
      UserData:
        Fn::Base64: !Sub
        - '{"ignition":{"config":{"merge":[{"source":"${SOURCE}"}]},"security":{"tls":
{"certificateAuthorities":[{"source":"${CA_BUNDLE}"}]}},"version":"3.1.0"}}'
        - {
          SOURCE: !Ref IgnitionLocation,
          CA_BUNDLE: !Ref CertificateAuthorities,
        }
      Tags:
      - Key: !Join ["", ["kubernetes.io/cluster/", !Ref InfrastructureName]]
        Value: "shared"

  RegisterMaster0:
    Condition: DoRegistration
```

```
    Type: Custom::NLBRegister
    Properties:
      ServiceToken: !Ref RegisterNlbIpTargetsLambdaArn
      TargetArn: !Ref ExternalApiTargetGroupArn
      TargetIp: !GetAtt Master0.PrivateIp

  RegisterMaster0InternalApiTarget:
    Condition: DoRegistration
    Type: Custom::NLBRegister
    Properties:
      ServiceToken: !Ref RegisterNlbIpTargetsLambdaArn
      TargetArn: !Ref InternalApiTargetGroupArn
      TargetIp: !GetAtt Master0.PrivateIp

  RegisterMaster0InternalServiceTarget:
    Condition: DoRegistration
    Type: Custom::NLBRegister
    Properties:
      ServiceToken: !Ref RegisterNlbIpTargetsLambdaArn
      TargetArn: !Ref InternalServiceTargetGroupArn
      TargetIp: !GetAtt Master0.PrivateIp

  Master1:
    Type: AWS::EC2::Instance
    Properties:
      ImageId: !Ref RhcosAmi
      BlockDeviceMappings:
      - DeviceName: /dev/xvda
        Ebs:
          VolumeSize: "120"
          VolumeType: "gp2"
      IamInstanceProfile: !Ref MasterInstanceProfileName
      InstanceType: !Ref MasterInstanceType
      NetworkInterfaces:
      - AssociatePublicIpAddress: "false"
        DeviceIndex: "0"
        GroupSet:
        - !Ref "MasterSecurityGroupId"
        SubnetId: !Ref "Master1Subnet"
      UserData:
        Fn::Base64: !Sub
        - '{"ignition":{"config":{"merge":[{"source":"${SOURCE}"}]},"security":{"tls":
{"certificateAuthorities":[{"source":"${CA_BUNDLE}"}]}},"version":"3.1.0"}}'
        - {
          SOURCE: !Ref IgnitionLocation,
          CA_BUNDLE: !Ref CertificateAuthorities,
        }
      Tags:
      - Key: !Join ["", ["kubernetes.io/cluster/", !Ref InfrastructureName]]
        Value: "shared"

  RegisterMaster1:
    Condition: DoRegistration
    Type: Custom::NLBRegister
    Properties:
      ServiceToken: !Ref RegisterNlbIpTargetsLambdaArn
```

```
      TargetArn: !Ref ExternalApiTargetGroupArn
      TargetIp: !GetAtt Master1.PrivateIp

  RegisterMaster1InternalApiTarget:
    Condition: DoRegistration
    Type: Custom::NLBRegister
    Properties:
      ServiceToken: !Ref RegisterNlbIpTargetsLambdaArn
      TargetArn: !Ref InternalApiTargetGroupArn
      TargetIp: !GetAtt Master1.PrivateIp

  RegisterMaster1InternalServiceTarget:
    Condition: DoRegistration
    Type: Custom::NLBRegister
    Properties:
      ServiceToken: !Ref RegisterNlbIpTargetsLambdaArn
      TargetArn: !Ref InternalServiceTargetGroupArn
      TargetIp: !GetAtt Master1.PrivateIp

  Master2:
    Type: AWS::EC2::Instance
    Properties:
      ImageId: !Ref RhcosAmi
      BlockDeviceMappings:
      - DeviceName: /dev/xvda
        Ebs:
          VolumeSize: "120"
          VolumeType: "gp2"
      IamInstanceProfile: !Ref MasterInstanceProfileName
      InstanceType: !Ref MasterInstanceType
      NetworkInterfaces:
      - AssociatePublicIpAddress: "false"
        DeviceIndex: "0"
        GroupSet:
        - !Ref "MasterSecurityGroupId"
        SubnetId: !Ref "Master2Subnet"
      UserData:
        Fn::Base64: !Sub
        - '{"ignition":{"config":{"merge":[{"source":"${SOURCE}"}]},"security":{"tls":
{"certificateAuthorities":[{"source":"${CA_BUNDLE}"}]}},"version":"3.1.0"}}'
        - {
          SOURCE: !Ref IgnitionLocation,
          CA_BUNDLE: !Ref CertificateAuthorities,
        }
      Tags:
      - Key: !Join ["", ["kubernetes.io/cluster/", !Ref InfrastructureName]]
        Value: "shared"

  RegisterMaster2:
    Condition: DoRegistration
    Type: Custom::NLBRegister
    Properties:
      ServiceToken: !Ref RegisterNlbIpTargetsLambdaArn
      TargetArn: !Ref ExternalApiTargetGroupArn
      TargetIp: !GetAtt Master2.PrivateIp
```

```
  RegisterMaster2InternalApiTarget:
    Condition: DoRegistration
    Type: Custom::NLBRegister
    Properties:
      ServiceToken: !Ref RegisterNlbIpTargetsLambdaArn
      TargetArn: !Ref InternalApiTargetGroupArn
      TargetIp: !GetAtt Master2.PrivateIp

  RegisterMaster2InternalServiceTarget:
    Condition: DoRegistration
    Type: Custom::NLBRegister
    Properties:
      ServiceToken: !Ref RegisterNlbIpTargetsLambdaArn
      TargetArn: !Ref InternalServiceTargetGroupArn
      TargetIp: !GetAtt Master2.PrivateIp

Outputs:
  PrivateIPs:
    Description: The control-plane node private IP addresses.
    Value:
      !Join [
        ",",
        [!GetAtt Master0.PrivateIp, !GetAtt Master1.PrivateIp, !GetAtt Master2.PrivateIp]
      ]
```

5.14.16. Creating the worker nodes in AWS

You can create worker nodes in Amazon Web Services (AWS) for your cluster to use.

You can use the provided CloudFormation template and a custom parameter file to create a stack of AWS resources that represent a worker node.

IMPORTANT

The CloudFormation template creates a stack that represents one worker node. You must create a stack for each worker node.

NOTE

If you do not use the provided CloudFormation template to create your worker nodes, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

Prerequisites

- You configured an AWS account.
- You added your AWS keys and region to your local AWS profile by running **aws configure**.
- You generated the Ignition config files for your cluster.
- You created and configured a VPC and associated subnets in AWS.

- You created and configured DNS, load balancers, and listeners in AWS.
- You created the security groups and roles required for your cluster in AWS.
- You created the bootstrap machine.
- You created the control plane machines.

Procedure

1. Create a JSON file that contains the parameter values that the CloudFormation template requires:

```
[
  {
    "ParameterKey": "InfrastructureName", 1
    "ParameterValue": "mycluster-<random_string>" 2
  },
  {
    "ParameterKey": "RhcosAmi", 3
    "ParameterValue": "ami-<random_string>" 4
  },
  {
    "ParameterKey": "Subnet", 5
    "ParameterValue": "subnet-<random_string>" 6
  },
  {
    "ParameterKey": "WorkerSecurityGroupId", 7
    "ParameterValue": "sg-<random_string>" 8
  },
  {
    "ParameterKey": "IgnitionLocation", 9
    "ParameterValue": "https://api-int.<cluster_name>.<domain_name>:22623/config/worker"
10
  },
  {
    "ParameterKey": "CertificateAuthorities", 11
    "ParameterValue": "" 12
  },
  {
    "ParameterKey": "WorkerInstanceProfileName", 13
    "ParameterValue": "" 14
  },
  {
    "ParameterKey": "WorkerInstanceType", 15
    "ParameterValue": "" 16
  }
]
```

1. The name for your cluster infrastructure that is encoded in your Ignition config files for the cluster.
2. Specify the infrastructure name that you extracted from the Ignition config file metadata, which has the format **<cluster-name>-<random-string>**.

3. Current Red Hat Enterprise Linux CoreOS (RHCOS) AMI to use for the worker nodes based on your selected architecture.
4. Specify an **AWS::EC2::Image::Id** value.
5. A subnet, preferably private, to start the worker nodes on.
6. Specify a subnet from the **PrivateSubnets** value from the output of the CloudFormation template for DNS and load balancing.
7. The worker security group ID to associate with worker nodes.
8. Specify the **WorkerSecurityGroupId** value from the output of the CloudFormation template for the security group and roles.
9. The location to fetch the bootstrap Ignition config file from.
10. Specify the generated Ignition config location, **https://api-int.<cluster_name>.<domain_name>:22623/config/worker**.
11. Base64 encoded certificate authority string to use.
12. Specify the value from the **worker.ign** file that is in the installation directory. This value is the long string with the format **data:text/plain;charset=utf-8;base64,ABC...xYz==**.
13. The IAM profile to associate with worker nodes.
14. Specify the **WorkerInstanceProfile** parameter value from the output of the CloudFormation template for the security group and roles.
15. The type of AWS instance to use for the compute machines based on your selected architecture.
16. The instance type value corresponds to the minimum resource requirements for compute machines. For example **m6i.large** is a type for AMD64. and **m6g.large** is a type for ARM64.

2. Copy the template from the **CloudFormation template for worker machines** section of this topic and save it as a YAML file on your computer. This template describes the networking objects and load balancers that your cluster requires.
3. Optional: If you specified an **m5** instance type as the value for **WorkerInstanceType**, add that instance type to the **WorkerInstanceType.AllowedValues** parameter in the CloudFormation template.
4. Optional: If you are deploying with an AWS Marketplace image, update the **Worker0.type.properties.ImageID** parameter with the AMI ID that you obtained from your subscription.
5. Use the CloudFormation template to create a stack of AWS resources that represent a worker node:

IMPORTANT

You must enter the command on a single line.

-

```
$ aws cloudformation create-stack --stack-name <name> 1
    --template-body file://<template>.yaml \ 2
    --parameters file://<parameters>.json 3
```

1 **<name>** is the name for the CloudFormation stack, such as **cluster-worker-1**. You need the name of this stack if you remove the cluster.

2 **<template>** is the relative path to and name of the CloudFormation template YAML file that you saved.

3 **<parameters>** is the relative path to and name of the CloudFormation parameters JSON file.

Example output

```
arn:aws:cloudformation:us-east-1:269333783861:stack/cluster-worker-1/729ee301-1c2a-11eb-348f-sd9888c65b59
```

NOTE

The CloudFormation template creates a stack that represents one worker node.

6. Confirm that the template components exist:

```
$ aws cloudformation describe-stacks --stack-name <name>
```

7. Continue to create worker stacks until you have created enough worker machines for your cluster. You can create additional worker stacks by referencing the same template and parameter files and specifying a different stack name.

IMPORTANT

You must create at least two worker machines, so you must create at least two stacks that use this CloudFormation template.

5.14.16.1. CloudFormation template for worker machines

You can use the following CloudFormation template to deploy the worker machines that you need for your OpenShift Container Platform cluster.

Example 5.70. CloudFormation template for worker machines

```
AWSTemplateFormatVersion: 2010-09-09
Description: Template for OpenShift Cluster Node Launch (EC2 worker instance)

Parameters:
  InfrastructureName:
    AllowedPattern: ^([a-zA-Z][a-zA-Z0-9\-]{0,26})$
    MaxLength: 27
    MinLength: 1
    ConstraintDescription: Infrastructure name must be alphanumeric, start with a letter, and have a
maximum of 27 characters.
```

```
    Description: A short, unique cluster ID used to tag nodes for the kubelet cloud provider.
    Type: String
  RhcosAmi:
    Description: Current Red Hat Enterprise Linux CoreOS AMI to use for bootstrap.
    Type: AWS::EC2::Image::Id
  Subnet:
    Description: The subnets, recommend private, to launch the master nodes into.
    Type: AWS::EC2::Subnet::Id
  WorkerSecurityGroupId:
    Description: The master security group ID to associate with master nodes.
    Type: AWS::EC2::SecurityGroup::Id
  IgnitionLocation:
    Default: https://api-int.$CLUSTER_NAME.$DOMAIN:22623/config/worker
    Description: Ignition config file location.
    Type: String
  CertificateAuthorities:
    Default: data:text/plain;charset=utf-8;base64,ABC...xYz==
    Description: Base64 encoded certificate authority string to use.
    Type: String
  WorkerInstanceProfileName:
    Description: IAM profile to associate with master nodes.
    Type: String
  WorkerInstanceType:
    Default: m5.large
    Type: String

Metadata:
  AWS::CloudFormation::Interface:
    ParameterGroups:
    - Label:
        default: "Cluster Information"
      Parameters:
      - InfrastructureName
    - Label:
        default: "Host Information"
      Parameters:
      - WorkerInstanceType
      - RhcosAmi
      - IgnitionLocation
      - CertificateAuthorities
      - WorkerSecurityGroupId
      - WorkerInstanceProfileName
    - Label:
        default: "Network Configuration"
      Parameters:
      - Subnet
    ParameterLabels:
      Subnet:
        default: "Subnet"
      InfrastructureName:
        default: "Infrastructure Name"
      WorkerInstanceType:
        default: "Worker Instance Type"
      WorkerInstanceProfileName:
        default: "Worker Instance Profile Name"
      RhcosAmi:
```

```
        default: "Red Hat Enterprise Linux CoreOS AMI ID"
      IgnitionLocation:
        default: "Worker Ignition Source"
      CertificateAuthorities:
        default: "Ignition CA String"
      WorkerSecurityGroupId:
        default: "Worker Security Group ID"

Resources:
  Worker0:
    Type: AWS::EC2::Instance
    Properties:
      ImageId: !Ref RhcosAmi
      BlockDeviceMappings:
      - DeviceName: /dev/xvda
        Ebs:
          VolumeSize: "120"
          VolumeType: "gp2"
      IamInstanceProfile: !Ref WorkerInstanceProfileName
      InstanceType: !Ref WorkerInstanceType
      NetworkInterfaces:
      - AssociatePublicIpAddress: "false"
        DeviceIndex: "0"
        GroupSet:
        - !Ref "WorkerSecurityGroupId"
        SubnetId: !Ref "Subnet"
      UserData:
        Fn::Base64: !Sub
        - '{"ignition":{"config":{"merge":[{"source":"${SOURCE}"}]},"security":{"tls":
{"certificateAuthorities":[{"source":"${CA_BUNDLE}"}]}},"version":"3.1.0"}}'
        - {
          SOURCE: !Ref IgnitionLocation,
          CA_BUNDLE: !Ref CertificateAuthorities,
        }
      Tags:
      - Key: !Join ["", ["kubernetes.io/cluster/", !Ref InfrastructureName]]
        Value: "shared"

Outputs:
  PrivateIP:
    Description: The compute node private IP address.
    Value: !GetAtt Worker0.PrivateIp
```

5.14.17. Initializing the bootstrap sequence on AWS with user-provisioned infrastructure

After you create all of the required infrastructure in Amazon Web Services (AWS), you can start the bootstrap sequence that initializes the OpenShift Container Platform control plane.

Prerequisites

- You configured an AWS account.
- You added your AWS keys and region to your local AWS profile by running **aws configure**.

- You generated the Ignition config files for your cluster.
- You created and configured a VPC and associated subnets in AWS.
- You created and configured DNS, load balancers, and listeners in AWS.
- You created the security groups and roles required for your cluster in AWS.
- You created the bootstrap machine.
- You created the control plane machines.
- You created the worker nodes.

Procedure

1. Change to the directory that contains the installation program and start the bootstrap process that initializes the OpenShift Container Platform control plane:

```
$ ./openshift-install wait-for bootstrap-complete --dir <installation_directory> \ 1
    --log-level=info 2
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

Example output

```
INFO Waiting up to 20m0s for the Kubernetes API at
https://api.mycluster.example.com:6443...
INFO API v1.24.0 up
INFO Waiting up to 30m0s for bootstrapping to complete...
INFO It is now safe to remove the bootstrap resources
INFO Time elapsed: 1s
```

If the command exits without a **FATAL** warning, your OpenShift Container Platform control plane has initialized.

NOTE

After the control plane initializes, it sets up the compute nodes and installs additional services in the form of Operators.

Additional resources

- See Monitoring installation progress for details about monitoring the installation, bootstrap, and control plane logs as an OpenShift Container Platform installation progresses.
- See Gathering bootstrap node diagnostic data for information about troubleshooting issues related to the bootstrap process.

5.14.18. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

Example output

```
system:admin
```

5.14.19. Approving the certificate signing requests for your machines

When you add machines to a cluster, two pending certificate signing requests (CSRs) are generated for each machine that you added. You must confirm that these CSRs are approved or, if necessary, approve them yourself. The client requests must be approved first, followed by the server requests.

Prerequisites

- You added machines to your cluster.

Procedure

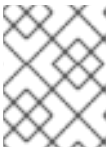
1. Confirm that the cluster recognizes the machines:

```
$ oc get nodes
```

Example output

```
NAME      STATUS    ROLES   AGE  VERSION
master-0  Ready     master  63m  v1.24.0
master-1  Ready     master  63m  v1.24.0
master-2  Ready     master  64m  v1.24.0
```

The output lists all of the machines that you created.



NOTE

The preceding output might not include the compute nodes, also known as worker nodes, until some CSRs are approved.

2. Review the pending CSRs and ensure that you see the client requests with the **Pending** or **Approved** status for each machine that you added to the cluster:

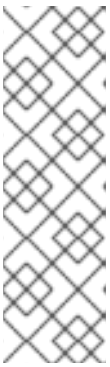
```
$ oc get csr
```

Example output

```
NAME        AGE    REQUESTOR                                                   CONDITION
csr-8b2br   15m    system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper   Pending
csr-8vnps   15m    system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper   Pending
...
```

In this example, two machines are joining the cluster. You might see more approved CSRs in the list.

3. If the CSRs were not approved, after all of the pending CSRs for the machines you added are in **Pending** status, approve the CSRs for your cluster machines:



NOTE

Because the CSRs rotate automatically, approve your CSRs within an hour of adding the machines to the cluster. If you do not approve them within an hour, the certificates will rotate, and more than two certificates will be present for each node. You must approve all of these certificates. After the client CSR is approved, the Kubelet creates a secondary CSR for the serving certificate, which requires manual approval. Then, subsequent serving certificate renewal requests are automatically approved by the **machine-approver** if the Kubelet requests a new certificate with identical parameters.

NOTE

For clusters running on platforms that are not machine API enabled, such as bare metal and other user-provisioned infrastructure, you must implement a method of automatically approving the kubelet serving certificate requests (CSRs). If a request is not approved, then the **oc exec**, **oc rsh**, and **oc logs** commands cannot succeed, because a serving certificate is required when the API server connects to the kubelet. Any operation that contacts the Kubelet endpoint requires this certificate approval to be in place. The method must watch for new CSRs, confirm that the CSR was submitted by the **node-bootstrapper** service account in the **system:node** or **system:admin** groups, and confirm the identity of the node.

- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

1 **<csr_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{{"\n"}}
{{end}}{{end}}' | xargs --no-run-if-empty oc adm certificate approve
```

NOTE

Some Operators might not become available until some CSRs are approved.

4. Now that your client requests are approved, you must review the server requests for each machine that you added to the cluster:

```
$ oc get csr
```

Example output

```
NAME        AGE     REQUESTOR                                                   CONDITION
csr-bfd72   5m26s   system:node:ip-10-0-50-126.us-east-2.compute.internal
Pending
csr-c57lv   5m26s   system:node:ip-10-0-95-157.us-east-2.compute.internal
Pending
...
```

5. If the remaining CSRs are not approved, and are in the **Pending** status, approve the CSRs for your cluster machines:

- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

1 **<csr_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{{"\n"}}
{{end}}{{end}}' | xargs oc adm certificate approve
```

6. After all client and server CSRs have been approved, the machines have the **Ready** status. Verify this by running the following command:

```
$ oc get nodes
```

Example output

```
NAME      STATUS    ROLES   AGE  VERSION
master-0  Ready     master  73m  v1.24.0
```

```
master-1  Ready    master  73m  v1.24.0
master-2  Ready    master  74m  v1.24.0
worker-0  Ready    worker  11m  v1.24.0
worker-1  Ready    worker  11m  v1.24.0
```

NOTE

It can take a few minutes after approval of the server CSRs for the machines to transition to the **Ready** status.

Additional information

- For more information on CSRs, see Certificate Signing Requests.

5.14.20. Initial Operator configuration

After the control plane initializes, you must immediately configure some Operators so that they all become available.

Prerequisites

- Your control plane has initialized.

Procedure

1. Watch the cluster components come online:

```
$ watch -n5 oc get clusteroperators
```

Example output

```
NAME                                       VERSION   AVAILABLE   PROGRESSING   DEGRADED
SINCE
authentication                             4.11.0    True        False         False      19m
baremetal                                  4.11.0    True        False         False      37m
cloud-credential                           4.11.0    True        False         False      40m
cluster-autoscaler                         4.11.0    True        False         False      37m
config-operator                            4.11.0    True        False         False      38m
console                                    4.11.0    True        False         False      26m
csi-snapshot-controller                    4.11.0    True        False         False      37m
dns                                        4.11.0    True        False         False      37m
etcd                                       4.11.0    True        False         False      36m
image-registry                             4.11.0    True        False         False      31m
ingress                                    4.11.0    True        False         False      30m
insights                                   4.11.0    True        False         False      31m
kube-apiserver                             4.11.0    True        False         False      26m
kube-controller-manager                    4.11.0    True        False         False      36m
kube-scheduler                             4.11.0    True        False         False      36m
kube-storage-version-migrator              4.11.0    True        False         False      37m
machine-api                                4.11.0    True        False         False      29m
machine-approver                           4.11.0    True        False         False      37m
machine-config                             4.11.0    True        False         False      36m
marketplace                                4.11.0    True        False         False      37m
monitoring                                 4.11.0    True        False         False      29m
```

```
network                                    4.11.0    True        False         False      38m
node-tuning                                4.11.0    True        False         False      37m
openshift-apiserver                        4.11.0    True        False         False      32m
openshift-controller-manager               4.11.0    True        False         False      30m
openshift-samples                          4.11.0    True        False         False      32m
operator-lifecycle-manager                 4.11.0    True        False         False      37m
operator-lifecycle-manager-catalog         4.11.0    True        False         False      37m
operator-lifecycle-manager-packageserver   4.11.0    True        False         False      32m
service-ca                                 4.11.0    True        False         False      38m
storage                                    4.11.0    True        False         False      37m
```

2. Configure the Operators that are not available.

5.14.20.1. Disabling the default OperatorHub sources

Operator catalogs that source content provided by Red Hat and community projects are configured for OperatorHub by default during an OpenShift Container Platform installation. In a restricted network environment, you must disable the default catalogs as a cluster administrator.

Procedure

- Disable the sources for the default catalogs by adding **disableAllDefaultSources: true** to the **OperatorHub** object:

```
$ oc patch OperatorHub cluster --type json \
    -p '[{"op": "add", "path": "/spec/disableAllDefaultSources", "value": true}]'
```

TIP

Alternatively, you can use the web console to manage catalog sources. From the **Administration → Cluster Settings → Configuration → OperatorHub** page, click the **Sources** tab, where you can create, update, delete, disable, and enable individual sources.

5.14.20.2. Image registry storage configuration

Amazon Web Services provides default storage, which means the Image Registry Operator is available after installation. However, if the Registry Operator cannot create an S3 bucket and automatically configure storage, you must manually configure registry storage.

Instructions are shown for configuring a persistent volume, which is required for production clusters. Where applicable, instructions are shown for configuring an empty directory as the storage location, which is available for only non-production clusters.

Additional instructions are provided for allowing the image registry to use block storage types by using the **Recreate** rollout strategy during upgrades.

5.14.20.2.1. Configuring registry storage for AWS with user-provisioned infrastructure

During installation, your cloud credentials are sufficient to create an Amazon S3 bucket and the Registry Operator will automatically configure storage.

If the Registry Operator cannot create an S3 bucket and automatically configure storage, you can create an S3 bucket and configure storage with the following procedure.

Prerequisites

- You have a cluster on AWS with user-provisioned infrastructure.
- For Amazon S3 storage, the secret is expected to contain two keys:
  - **REGISTRY_STORAGE_S3_ACCESSKEY**
  - **REGISTRY_STORAGE_S3_SECRETKEY**

Procedure

Use the following procedure if the Registry Operator cannot create an S3 bucket and automatically configure storage.

1. Set up a Bucket Lifecycle Policy to abort incomplete multipart uploads that are one day old.
2. Fill in the storage configuration in **configs.imageregistry.operator.openshift.io/cluster**:

```
$ oc edit configs.imageregistry.operator.openshift.io/cluster
```

Example configuration

```
storage:
  s3:
    bucket: <bucket-name>
    region: <region-name>
```

WARNING

To secure your registry images in AWS, block public access to the S3 bucket.

5.14.20.2.2. Configuring storage for the image registry in non-production clusters

You must configure storage for the Image Registry Operator. For non-production clusters, you can set the image registry to an empty directory. If you do so, all images are lost if you restart the registry.

Procedure

- To set the image registry storage to an empty directory:

```
$ oc patch configs.imageregistry.operator.openshift.io cluster --type merge --patch '{"spec":
{"storage":{"emptyDir":{}}}}'
```

WARNING

Configure this option for only non-production clusters.

If you run this command before the Image Registry Operator initializes its components, the **oc patch** command fails with the following error:

```
Error from server (NotFound): configs.imageregistry.operator.openshift.io "cluster" not found
```

Wait a few minutes and run the command again.

5.14.21. Deleting the bootstrap resources

After you complete the initial Operator configuration for the cluster, remove the bootstrap resources from Amazon Web Services (AWS).

Prerequisites

- You completed the initial Operator configuration for your cluster.

Procedure

1. Delete the bootstrap resources. If you used the CloudFormation template, delete its stack:
   - Delete the stack by using the AWS CLI:

     ```
     $ aws cloudformation delete-stack --stack-name <name> 1
     ```

     1 **<name>** is the name of your bootstrap stack.

   - Delete the stack by using the AWS CloudFormation console.

5.14.22. Creating the Ingress DNS Records

If you removed the DNS Zone configuration, manually create DNS records that point to the Ingress load balancer. You can create either a wildcard record or specific records. While the following procedure uses A records, you can use other record types that you require, such as CNAME or alias.

Prerequisites

- You deployed an OpenShift Container Platform cluster on Amazon Web Services (AWS) that uses infrastructure that you provisioned.
- You installed the OpenShift CLI (**oc**).
- You installed the **jq** package.
- You downloaded the AWS CLI and installed it on your computer. See Install the AWS CLI Using the Bundled Installer (Linux, macOS, or Unix).

Procedure

1. Determine the routes to create.

   - To create a wildcard record, use ***.apps.<cluster_name>.<domain_name>**, where **<cluster_name>** is your cluster name, and **<domain_name>** is the Route 53 base domain for your OpenShift Container Platform cluster.
   - To create specific records, you must create a record for each route that your cluster uses, as shown in the output of the following command:

     ```
     $ oc get --all-namespaces -o jsonpath='{range .items[*]}{range .status.ingress[*]}{.host}
     {"\n"}{end}{end}' routes
     ```

     Example output

     ```
     oauth-openshift.apps.<cluster_name>.<domain_name>
     console-openshift-console.apps.<cluster_name>.<domain_name>
     downloads-openshift-console.apps.<cluster_name>.<domain_name>
     alertmanager-main-openshift-monitoring.apps.<cluster_name>.<domain_name>
     prometheus-k8s-openshift-monitoring.apps.<cluster_name>.<domain_name>
     ```

2. Retrieve the Ingress Operator load balancer status and note the value of the external IP address that it uses, which is shown in the **EXTERNAL-IP** column:

   ```
   $ oc -n openshift-ingress get service router-default
   ```

   Example output

   ```
   NAME              TYPE           CLUSTER-IP      EXTERNAL-IP                            PORT(S)
   AGE
   router-default    LoadBalancer   172.30.62.215   ab3...28.us-east-2.elb.amazonaws.com
   80:31499/TCP,443:30693/TCP   5m
   ```

3. Locate the hosted zone ID for the load balancer:

   ```
   $ aws elb describe-load-balancers | jq -r '.LoadBalancerDescriptions[] | select(.DNSName ==
   "<external_ip>").CanonicalHostedZoneNameID' 1
   ```

   1 For **<external_ip>**, specify the value of the external IP address of the Ingress Operator load balancer that you obtained.

   Example output

   ```
   Z3AADJGX6KTTL2
   ```

   The output of this command is the load balancer hosted zone ID.

4. Obtain the public hosted zone ID for your cluster's domain:

   ```
   $ aws route53 list-hosted-zones-by-name \
           --dns-name "<domain_name>" \ 1
   ```

```
        --query 'HostedZones[? Config.PrivateZone != `true` && Name ==
`<domain_name>.`].Id' 2
        --output text
```

1 2 For **<domain_name>**, specify the Route 53 base domain for your OpenShift Container Platform cluster.

Example output

```
/hostedzone/Z3URY6TWQ91KVV
```

The public hosted zone ID for your domain is shown in the command output. In this example, it is **Z3URY6TWQ91KVV**.

5. Add the alias records to your private zone:

```
$ aws route53 change-resource-record-sets --hosted-zone-id "<private_hosted_zone_id>" --
change-batch '{ 1
>   "Changes": [
>     {
>       "Action": "CREATE",
>       "ResourceRecordSet": {
>         "Name": "\\052.apps.<cluster_domain>", 2
>         "Type": "A",
>         "AliasTarget":{
>           "HostedZoneId": "<hosted_zone_id>", 3
>           "DNSName": "<external_ip>.", 4
>           "EvaluateTargetHealth": false
>         }
>       }
>     }
>   ]
> }'
```

1 For **<private_hosted_zone_id>**, specify the value from the output of the CloudFormation template for DNS and load balancing.

2 For **<cluster_domain>**, specify the domain or subdomain that you use with your OpenShift Container Platform cluster.

3 For **<hosted_zone_id>**, specify the public hosted zone ID for the load balancer that you obtained.

4 For **<external_ip>**, specify the value of the external IP address of the Ingress Operator load balancer. Ensure that you include the trailing period (**.**) in this parameter value.

6. Add the records to your public zone:

```
$ aws route53 change-resource-record-sets --hosted-zone-id "<public_hosted_zone_id>"" --
change-batch '{ 1
>   "Changes": [
>     {
>       "Action": "CREATE",
```

```
>       "ResourceRecordSet": {
>         "Name": "\\052.apps.<cluster_domain>", 2
>         "Type": "A",
>         "AliasTarget":{
>           "HostedZoneId": "<hosted_zone_id>", 3
>           "DNSName": "<external_ip>.", 4
>           "EvaluateTargetHealth": false
>         }
>       }
>     }
>   ]
> }'
```

1. For **<public_hosted_zone_id>**, specify the public hosted zone for your domain.
2. For **<cluster_domain>**, specify the domain or subdomain that you use with your OpenShift Container Platform cluster.
3. For **<hosted_zone_id>**, specify the public hosted zone ID for the load balancer that you obtained.
4. For **<external_ip>**, specify the value of the external IP address of the Ingress Operator load balancer. Ensure that you include the trailing period (**.**) in this parameter value.

5.14.23. Completing an AWS installation on user-provisioned infrastructure

After you start the OpenShift Container Platform installation on Amazon Web Service (AWS) user-provisioned infrastructure, monitor the deployment to completion.

Prerequisites

- You removed the bootstrap node for an OpenShift Container Platform cluster on user-provisioned AWS infrastructure.
- You installed the **oc** CLI.

Procedure

1. From the directory that contains the installation program, complete the cluster installation:

```
$ ./openshift-install --dir <installation_directory> wait-for install-complete 1
```

1. For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

Example output

```
INFO Waiting up to 40m0s for the cluster at https://api.mycluster.example.com:6443 to
initialize...
INFO Waiting up to 10m0s for the openshift-console route to be created...
INFO Install complete!
INFO To access the cluster as the system:admin user when using 'oc', run 'export
KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
```

```
INFO Access the OpenShift web-console here: https://console-openshift-
console.apps.mycluster.example.com
INFO Login to the console with user: "kubeadmin", and password: "password"
INFO Time elapsed: 1s
```

IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

2. Register your cluster on the Cluster registration page.

5.14.24. Logging in to the cluster by using the web console

The **kubeadmin** user exists by default after an OpenShift Container Platform installation. You can log in to your cluster as the **kubeadmin** user by using the OpenShift Container Platform web console.

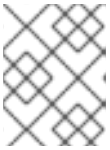
Prerequisites

- You have access to the installation host.
- You completed a cluster installation and all cluster Operators are available.

Procedure

1. Obtain the password for the **kubeadmin** user from the **kubeadmin-password** file on the installation host:

```
$ cat <installation_directory>/auth/kubeadmin-password
```

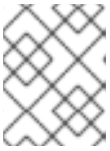


NOTE

Alternatively, you can obtain the **kubeadmin** password from the **<installation_directory>/.openshift_install.log** log file on the installation host.

2. List the OpenShift Container Platform web console route:

```
$ oc get routes -n openshift-console | grep 'console-openshift'
```



NOTE

Alternatively, you can obtain the OpenShift Container Platform route from the **<installation_directory>/.openshift_install.log** log file on the installation host.

Example output

```
console     console-openshift-console.apps.<cluster_name>.<base_domain>          console
https   reencrypt/Redirect   None
```

3. Navigate to the route detailed in the output of the preceding command in a web browser and log in as the **kubeadmin** user.

Additional resources

- See Accessing the web console for more details about accessing and understanding the OpenShift Container Platform web console.

5.14.25. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.11, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to OpenShift Cluster Manager Hybrid Cloud Console.

After you confirm that your OpenShift Cluster Manager Hybrid Cloud Console inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, use subscription watch to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

Additional resources

- See About remote health monitoring for more information about the Telemetry service

5.14.26. Additional resources

- See Working with stacks in the AWS documentation for more information about AWS CloudFormation stacks.

5.14.27. Next steps

- Validate an installation.
- Customize your cluster.
- Configure image streams for the Cluster Samples Operator and the **must-gather** tool.
- Learn how to use Operator Lifecycle Manager (OLM) on restricted networks .
- If the mirror registry that you used to install your cluster has a trusted CA, add it to the cluster by configuring additional trust stores.
- If necessary, you can opt out of remote health reporting .

- If necessary, see Registering your disconnected cluster
- If necessary, you can remove cloud provider credentials.

5.15. UNINSTALLING A CLUSTER ON AWS

You can remove a cluster that you deployed to Amazon Web Services (AWS).

5.15.1. Removing a cluster that uses installer-provisioned infrastructure

You can remove a cluster that uses installer-provisioned infrastructure from your cloud.

NOTE

After uninstallation, check your cloud provider for any resources not removed properly, especially with User Provisioned Infrastructure (UPI) clusters. There might be resources that the installer did not create or that the installer is unable to access.

Prerequisites

- You have a copy of the installation program that you used to deploy the cluster.
- You have the files that the installation program generated when you created your cluster.

Procedure

1. On the computer that you used to install the cluster, go to the directory that contains the installation program, and run the following command:

```
$ ./openshift-install destroy cluster \
--dir <installation_directory> --log-level info 1 2
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2 To view different details, specify **warn**, **debug**, or **error** instead of **info**.

NOTE

You must specify the directory that contains the cluster definition files for your cluster. The installation program requires the **metadata.json** file in this directory to delete the cluster.

2. Optional: Delete the **<installation_directory>** directory and the OpenShift Container Platform installation program.

5.15.2. Deleting AWS resources with the Cloud Credential Operator utility

To clean up resources after uninstalling an OpenShift Container Platform cluster with the Cloud Credential Operator (CCO) in manual mode with STS, you can use the CCO utility (**ccoctl**) to remove the AWS resources that **ccoctl** created during installation.

Prerequisites

- Extract and prepare the **ccoctl** binary.
- Install an OpenShift Container Platform cluster with the CCO in manual mode with STS.

Procedure

- Delete the AWS resources that **ccoctl** created:

```
$ ccoctl aws delete \
  --name=<name> \ 1
  --region=<aws_region> 2
```

1 **<name>** matches the name that was originally used to create and tag the cloud resources.

2 **<aws_region>** is the AWS region in which to delete cloud resources.

Example output:

```
2021/04/08 17:50:41 Identity Provider object .well-known/openid-configuration deleted from the bucket <name>-oidc
2021/04/08 17:50:42 Identity Provider object keys.json deleted from the bucket <name>-oidc
2021/04/08 17:50:43 Identity Provider bucket <name>-oidc deleted
2021/04/08 17:51:05 Policy <name>-openshift-cloud-credential-operator-cloud-credential-o associated with IAM Role <name>-openshift-cloud-credential-operator-cloud-credential-o deleted
2021/04/08 17:51:05 IAM Role <name>-openshift-cloud-credential-operator-cloud-credential-o deleted
2021/04/08 17:51:07 Policy <name>-openshift-cluster-csi-drivers-ebs-cloud-credentials associated with IAM Role <name>-openshift-cluster-csi-drivers-ebs-cloud-credentials deleted
2021/04/08 17:51:07 IAM Role <name>-openshift-cluster-csi-drivers-ebs-cloud-credentials deleted
2021/04/08 17:51:08 Policy <name>-openshift-image-registry-installer-cloud-credentials associated with IAM Role <name>-openshift-image-registry-installer-cloud-credentials deleted
2021/04/08 17:51:08 IAM Role <name>-openshift-image-registry-installer-cloud-credentials deleted
2021/04/08 17:51:09 Policy <name>-openshift-ingress-operator-cloud-credentials associated with IAM Role <name>-openshift-ingress-operator-cloud-credentials deleted
2021/04/08 17:51:10 IAM Role <name>-openshift-ingress-operator-cloud-credentials deleted
2021/04/08 17:51:11 Policy <name>-openshift-machine-api-aws-cloud-credentials associated with IAM Role <name>-openshift-machine-api-aws-cloud-credentials deleted
2021/04/08 17:51:11 IAM Role <name>-openshift-machine-api-aws-cloud-credentials deleted
2021/04/08 17:51:39 Identity Provider with ARN arn:aws:iam::<aws_account_id>:oidc-provider/<name>-oidc.s3.<aws_region>.amazonaws.com deleted
```

Verification

- To verify that the resources are deleted, query AWS. For more information, refer to AWS documentation.

CHAPTER 6. INSTALLING ON AZURE

6.1. PREPARING TO INSTALL ON AZURE

6.1.1. Prerequisites

- You reviewed details about the OpenShift Container Platform installation and update processes.
- You read the documentation on selecting a cluster installation method and preparing it for users.

6.1.2. Requirements for installing OpenShift Container Platform on Azure

Before installing OpenShift Container Platform on Microsoft Azure, you must configure an Azure account. See Configuring an Azure account for details about account configuration, account limits, public DNS zone configuration, required roles, creating service principals, and supported Azure regions.

If the cloud identity and access management (IAM) APIs are not accessible in your environment, or if you do not want to store an administrator-level credential secret in the **kube-system** namespace, see Manually creating IAM for Azure for other options.

6.1.3. Choosing a method to install OpenShift Container Platform on Azure

You can install OpenShift Container Platform on installer-provisioned or user-provisioned infrastructure. The default installation type uses installer-provisioned infrastructure, where the installation program provisions the underlying infrastructure for the cluster. You can also install OpenShift Container Platform on infrastructure that you provision. If you do not use infrastructure that the installation program provisions, you must manage and maintain the cluster resources yourself.

See Installation process for more information about installer-provisioned and user-provisioned installation processes.

6.1.3.1. Installing a cluster on installer-provisioned infrastructure

You can install a cluster on Azure infrastructure that is provisioned by the OpenShift Container Platform installation program, by using one of the following methods:

- **Installing a cluster quickly on Azure** You can install OpenShift Container Platform on Azure infrastructure that is provisioned by the OpenShift Container Platform installation program. You can install a cluster quickly by using the default configuration options.
- **Installing a customized cluster on Azure** You can install a customized cluster on Azure infrastructure that the installation program provisions. The installation program allows for some customization to be applied at the installation stage. Many other customization options are available post-installation.
- **Installing a cluster on Azure with network customizations** You can customize your OpenShift Container Platform network configuration during installation, so that your cluster can coexist with your existing IP address allocations and adhere to your network requirements.
- **Installing a cluster on Azure into an existing VNet** You can install OpenShift Container Platform on an existing Azure Virtual Network (VNet) on Azure. You can use this installation method if you have constraints set by the guidelines of your company, such as limits when

creating new accounts or infrastructure.

- **Installing a private cluster on Azure**: You can install a private cluster into an existing Azure Virtual Network (VNet) on Azure. You can use this method to deploy OpenShift Container Platform on an internal network that is not visible to the internet.

- **Installing a cluster on Azure into a government region**: OpenShift Container Platform can be deployed into Microsoft Azure Government (MAG) regions that are specifically designed for US government agencies at the federal, state, and local level, as well as contractors, educational institutions, and other US customers that must run sensitive workloads on Azure.

6.1.3.2. Installing a cluster on user-provisioned infrastructure

You can install a cluster on Azure infrastructure that you provision, by using the following method:

- **Installing a cluster on Azure using ARM templates**: You can install OpenShift Container Platform on Azure by using infrastructure that you provide. You can use the provided Azure Resource Manager (ARM) templates to assist with an installation.

6.1.4. Next steps

- Configuring an Azure account

6.2. CONFIGURING AN AZURE ACCOUNT

Before you can install OpenShift Container Platform, you must configure a Microsoft Azure account.

IMPORTANT

All Azure resources that are available through public endpoints are subject to resource name restrictions, and you cannot create resources that use certain terms. For a list of terms that Azure restricts, see Resolve reserved resource name errors in the Azure documentation.

6.2.1. Azure account limits

The OpenShift Container Platform cluster uses a number of Microsoft Azure components, and the default Azure subscription and service limits, quotas, and constraints affect your ability to install OpenShift Container Platform clusters.

IMPORTANT

Default limits vary by offer category types, such as Free Trial and Pay-As-You-Go, and by series, such as Dv2, F, and G. For example, the default for Enterprise Agreement subscriptions is 350 cores.

Check the limits for your subscription type and if necessary, increase quota limits for your account before you install a default cluster on Azure.

The following table summarizes the Azure components whose limits can impact your ability to install and run OpenShift Container Platform clusters.

Component	Number of components required by default	Default Azure limit	Description
vCPU	40	20 per region	A default cluster requires 40 vCPUs, so you must increase the account limit. By default, each cluster creates the following instances: • One bootstrap machine, which is removed after installation • Three control plane machines • Three compute machines Because the bootstrap machine uses **Standard_D4s_v3** machines, which use 4 vCPUs, the control plane machines use **Standard_D8s_v3** virtual machines, which use 8 vCPUs, and the worker machines use **Standard_D4s_v3** virtual machines, which use 4 vCPUs, a default cluster requires 40 vCPUs. The bootstrap node VM, which uses 4 vCPUs, is used only during installation. To deploy more worker nodes, enable autoscaling, deploy large workloads, or use a different instance type, you must further increase the vCPU limit for your account to ensure that your cluster can deploy the machines that you require.
OS Disk	7		Each cluster machine must have a minimum of 100 GB of storage and 300 IOPS. While these are the minimum supported values, faster storage is recommended for production clusters and clusters with intensive workloads. For more information about optimizing storage for performance, see the page titled "Optimizing storage" in the "Scalability and performance" section.
VNet	1	1000 per region	Each default cluster requires one Virtual Network (VNet), which contains two subnets.
Network interfaces	7	65,536 per region	Each default cluster requires seven network interfaces. If you create more machines or your deployed workloads create load balancers, your cluster uses more network interfaces.

Component	Number of components required by default	Default Azure limit	Description
Network security groups	2	5000	Each cluster creates network security groups for each subnet in the VNet. The default cluster creates network security groups for the control plane and for the compute node subnets: **controlplane** — Allows the control plane machines to be reached on port 6443 from anywhere **node** — Allows worker nodes to be reached from the internet on ports 80 and 443
Network load balancers	3	1000 per region	Each cluster creates the following load balancers: **default** — Public IP address that load balances requests to ports 80 and 443 across worker machines **internal** — Private IP address that load balances requests to ports 6443 and 22623 across control plane machines **external** — Public IP address that load balances requests to port 6443 across control plane machines If your applications create more Kubernetes **LoadBalancer** service objects, your cluster uses more load balancers.
Public IP addresses	3		Each of the two public load balancers uses a public IP address. The bootstrap machine also uses a public IP address so that you can SSH into the machine to troubleshoot issues during installation. The IP address for the bootstrap node is used only during installation.
Private IP addresses	7		The internal load balancer, each of the three control plane machines, and each of the three worker machines each use a private IP address.

Component	Number of components required by default	Default Azure limit	Description
Spot VM vCPUs (optional)	0 If you configure spot VMs, your cluster must have two spot VM vCPUs for every compute node.	20 per region	This is an optional component. To use spot VMs, you must increase the Azure default limit to at least twice the number of compute nodes in your cluster.  **NOTE** Using spot VMs for control plane nodes is not recommended.

Additional resources

- Optimizing storage.

6.2.2. Configuring a public DNS zone in Azure

To install OpenShift Container Platform, the Microsoft Azure account you use must have a dedicated public hosted DNS zone in your account. This zone must be authoritative for the domain. This service provides cluster DNS resolution and name lookup for external connections to the cluster.

Procedure

1. Identify your domain, or subdomain, and registrar. You can transfer an existing domain and registrar or obtain a new one through Azure or another source.

   NOTE

   For more information about purchasing domains through Azure, see Buy a custom domain name for Azure App Service in the Azure documentation.

2. If you are using an existing domain and registrar, migrate its DNS to Azure. See Migrate an active DNS name to Azure App Service in the Azure documentation.

3. Configure DNS for your domain. Follow the steps in the Tutorial: Host your domain in Azure DNS in the Azure documentation to create a public hosted zone for your domain or subdomain, extract the new authoritative name servers, and update the registrar records for the name servers that your domain uses.
   Use an appropriate root domain, such as **openshiftcorp.com**, or subdomain, such as **clusters.openshiftcorp.com**.

4. If you use a subdomain, follow your company's procedures to add its delegation records to the parent domain.

6.2.3. Increasing Azure account limits

To increase an account limit, file a support request on the Azure portal.

NOTE

You can increase only one type of quota per support request.

Procedure

1. From the Azure portal, click **Help + support** in the lower left corner.
2. Click **New support request** and then select the required values:
   a. From the **Issue type** list, select **Service and subscription limits (quotas)**
   b. From the **Subscription** list, select the subscription to modify.
   c. From the **Quota type** list, select the quota to increase. For example, select **Compute-VM (cores-vCPUs) subscription limit increases** to increase the number of vCPUs, which is required to install a cluster.
   d. Click **Next: Solutions**.
3. On the **Problem Details** page, provide the required information for your quota increase:
   a. Click **Provide details** and provide the required details in the **Quota details** window.
   b. In the SUPPORT METHOD and CONTACT INFO sections, provide the issue severity and your contact details.
4. Click **Next: Review + create** and then click **Create**.

6.2.4. Required Azure roles

OpenShift Container Platform needs a service principal so it can manage Microsoft Azure resources. Before you can create a service principal, review the following information:

Your Azure account subscription must have the following roles:

- **User Access Administrator**
- **Contributor**

Your Azure Active Directory (AD) must have the following permission:

- **"microsoft.directory/servicePrincipals/createAsOwner"**

To set roles on the Azure portal, see the Manage access to Azure resources using RBAC and the Azure portal in the Azure documentation.

6.2.5. Creating a service principal

Because OpenShift Container Platform and its installation program create Microsoft Azure resources by using the Azure Resource Manager, you must create a service principal to represent it.

Prerequisites

- Install or update the Azure CLI.
- Your Azure account has the required roles for the subscription that you use.

Procedure

1. Log in to the Azure CLI:

```
$ az login
```

2. If your Azure account uses subscriptions, ensure that you are using the right subscription:

   a. View the list of available accounts and record the **tenantId** value for the subscription you want to use for your cluster:

```
$ az account list --refresh
```

   Example output

```
[
  {
    "cloudName": "AzureCloud",
    "id": "9bab1460-96d5-40b3-a78e-17b15e978a80",
    "isDefault": true,
    "name": "Subscription Name",
    "state": "Enabled",
    "tenantId": "6057c7e9-b3ae-489d-a54e-de3f6bf6a8ee",
    "user": {
      "name": "you@example.com",
      "type": "user"
    }
  }
]
```

   b. View your active account details and confirm that the **tenantId** value matches the subscription you want to use:

```
$ az account show
```

   Example output

```
{
  "environmentName": "AzureCloud",
  "id": "9bab1460-96d5-40b3-a78e-17b15e978a80",
  "isDefault": true,
  "name": "Subscription Name",
  "state": "Enabled",
  "tenantId": "6057c7e9-b3ae-489d-a54e-de3f6bf6a8ee", (1)
  "user": {
    "name": "you@example.com",
    "type": "user"
  }
}
```

   (1) Ensure that the value of the **tenantId** parameter is the correct subscription ID.

   c. If you are not using the right subscription, change the active subscription:

```
$ az account set -s <subscription_id> 1
```

1 Specify the subscription ID.

d. Verify the subscription ID update:

```
$ az account show
```

Example output

```
{
  "environmentName": "AzureCloud",
  "id": "33212d16-bdf6-45cb-b038-f6565b61edda",
  "isDefault": true,
  "name": "Subscription Name",
  "state": "Enabled",
  "tenantId": "8049c7e9-c3de-762d-a54e-dc3f6be6a7ee",
  "user": {
    "name": "you@example.com",
    "type": "user"
  }
}
```

3. Record the **tenantId** and **id** parameter values from the output. You need these values during the OpenShift Container Platform installation.

4. Create the service principal for your account:

```
$ az ad sp create-for-rbac --role Contributor --name <service_principal> \ 1
  --scopes /subscriptions/<subscription_id> 2
  --years <years> 3
```

1 Specify the service principal name.

2 Specify the subscription ID.

3 Specify the number of years. By default, a service principal expires in one year. By using the **--years** option you can extend the validity of your service principal.

Example output

```
Creating 'Contributor' role assignment under scope '/subscriptions/<subscription_id>'
The output includes credentials that you must protect. Be sure that you do not
include these credentials in your code or check the credentials into your source
control. For more information, see https://aka.ms/azadsp-cli
{
  "appId": "ac461d78-bf4b-4387-ad16-7e32e328aec6",
  "displayName": <service_principal>",
  "password": "00000000-0000-0000-0000-000000000000",
  "tenantId": "8049c7e9-c3de-762d-a54e-dc3f6be6a7ee"
}
```

5. Record the values of the **appId** and **password** parameters from the previous output. You need these values during OpenShift Container Platform installation.

6. Assign the **User Access Administrator** role by running the following command:

```
$ az role assignment create --role "User Access Administrator" \
  --assignee-object-id $(az ad sp show --id <appId> --query id -o tsv) 1
```

1 Specify the **appId** parameter value for your service principal.

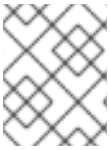
Additional resources

- For more information about CCO modes, see About the Cloud Credential Operator.

6.2.6. Supported Azure Marketplace regions

Installing a cluster using the Azure Marketplace image is available to customers who purchase the offer in North America and EMEA.

While the offer must be purchased in North America or EMEA, you can deploy the cluster to any of the Azure public partitions that OpenShift Container Platform supports.



NOTE

Deploying a cluster using the Azure Marketplace image is not supported for the Azure Government regions.

6.2.7. Supported Azure regions

The installation program dynamically generates the list of available Microsoft Azure regions based on your subscription.

Supported Azure public regions

- **australiacentral** (Australia Central)
- **australiaeast** (Australia East)
- **australiasoutheast** (Australia South East)
- **brazilsouth** (Brazil South)
- **canadacentral** (Canada Central)
- **canadaeast** (Canada East)
- **centralindia** (Central India)
- **centralus** (Central US)
- **eastasia** (East Asia)
- **eastus** (East US)
- **eastus2** (East US 2)

- **francecentral** (France Central)
- **germanywestcentral** (Germany West Central)
- **israelcentral** (Israel Central)
- **italynorth** (Italy North)
- **japaneast** (Japan East)
- **japanwest** (Japan West)
- **koreacentral** (Korea Central)
- **koreasouth** (Korea South)
- **northcentralus** (North Central US)
- **northeurope** (North Europe)
- **norwayeast** (Norway East)
- **polandcentral** (Poland Central)
- **qatarcentral** (Qatar Central)
- **southafricanorth** (South Africa North)
- **southcentralus** (South Central US)
- **southeastasia** (Southeast Asia)
- **southindia** (South India)
- **swedencentral** (Sweden Central)
- **switzerlandnorth** (Switzerland North)
- **uaenorth** (UAE North)
- **uksouth** (UK South)
- **ukwest** (UK West)
- **westcentralus** (West Central US)
- **westeurope** (West Europe)
- **westindia** (West India)
- **westus** (West US)
- **westus2** (West US 2)
- **westus3** (West US 3)

Supported Azure Government regions

Support for the following Microsoft Azure Government (MAG) regions was added in OpenShift Container Platform version 4.6:

- **usgovtexas** (US Gov Texas)
- **usgovvirginia** (US Gov Virginia)

You can reference all available MAG regions in the Azure documentation. Other provided MAG regions are expected to work with OpenShift Container Platform, but have not been tested.

6.2.8. Next steps

- Install an OpenShift Container Platform cluster on Azure. You can install a customized cluster or quickly install a cluster with default options.

6.3. MANUALLY CREATING IAM FOR AZURE

In environments where the cloud identity and access management (IAM) APIs are not reachable, or the administrator prefers not to store an administrator-level credential secret in the cluster **kube-system** namespace, you can put the Cloud Credential Operator (CCO) into manual mode before you install the cluster.

6.3.1. Alternatives to storing administrator-level secrets in the kube-system project

The Cloud Credential Operator (CCO) manages cloud provider credentials as Kubernetes custom resource definitions (CRDs). You can configure the CCO to suit the security requirements of your organization by setting different values for the **credentialsMode** parameter in the **install-config.yaml** file.

If you prefer not to store an administrator-level credential secret in the cluster **kube-system** project, you can set the **credentialsMode** parameter for the CCO to **Manual** when installing OpenShift Container Platform and manage your cloud credentials manually.

Using manual mode allows each cluster component to have only the permissions it requires, without storing an administrator-level credential in the cluster. You can also use this mode if your environment does not have connectivity to the cloud provider public IAM endpoint. However, you must manually reconcile permissions with new release images for every upgrade. You must also manually supply credentials for every component that requests them.

Additional resources

- For a detailed description of all available CCO credential modes and their supported platforms, see About the Cloud Credential Operator.

6.3.2. Manually create IAM

The Cloud Credential Operator (CCO) can be put into manual mode prior to installation in environments where the cloud identity and access management (IAM) APIs are not reachable, or the administrator prefers not to store an administrator-level credential secret in the cluster **kube-system** namespace.

Procedure

1. Change to the directory that contains the installation program and create the **install-config.yaml** file by running the following command:

```
$ openshift-install create install-config --dir <installation_directory>
```

where **<installation_directory>** is the directory in which the installation program creates files.

2. Edit the **install-config.yaml** configuration file so that it contains the **credentialsMode** parameter set to **Manual**.

Example install-config.yaml configuration file

```
apiVersion: v1
baseDomain: cluster1.example.com
credentialsMode: Manual 1
compute:
- architecture: amd64
  hyperthreading: Enabled
...
```

1 This line is added to set the **credentialsMode** parameter to **Manual**.

3. Generate the manifests by running the following command from the directory that contains the installation program:

```
$ openshift-install create manifests --dir <installation_directory>
```

where **<installation_directory>** is the directory in which the installation program creates files.

4. From the directory that contains the installation program, obtain details of the OpenShift Container Platform release image that your **openshift-install** binary is built to use by running the following command:

```
$ openshift-install version
```

Example output

```
release image quay.io/openshift-release-dev/ocp-release:4.y.z-x86_64
```

5. Locate all **CredentialsRequest** objects in this release image that target the cloud you are deploying on by running the following command:

```
$ oc adm release extract quay.io/openshift-release-dev/ocp-release:4.y.z-x86_64 \
  --credentials-requests \
  --cloud=azure
```

This command creates a YAML file for each **CredentialsRequest** object.

Sample CredentialsRequest object

```
apiVersion: cloudcredential.openshift.io/v1
kind: CredentialsRequest
metadata:
  name: <component-credentials-request>
  namespace: openshift-cloud-credential-operator
```

```
  ...
spec:
  providerSpec:
    apiVersion: cloudcredential.openshift.io/v1
    kind: AzureProviderSpec
    roleBindings:
    - role: Contributor
  ...
```

6. Create YAML files for secrets in the **openshift-install** manifests directory that you generated previously. The secrets must be stored using the namespace and secret name defined in the **spec.secretRef** for each **CredentialsRequest** object.

Sample CredentialsRequest object with secrets

```
apiVersion: cloudcredential.openshift.io/v1
kind: CredentialsRequest
metadata:
  name: <component-credentials-request>
  namespace: openshift-cloud-credential-operator
  ...
spec:
  providerSpec:
    apiVersion: cloudcredential.openshift.io/v1
    kind: AzureProviderSpec
    roleBindings:
    - role: Contributor
      ...
  secretRef:
    name: <component-secret>
    namespace: <component-namespace>
  ...
```

Sample Secret object

```
apiVersion: v1
kind: Secret
metadata:
  name: <component-secret>
  namespace: <component-namespace>
data:
  azure_subscription_id: <base64_encoded_azure_subscription_id>
  azure_client_id: <base64_encoded_azure_client_id>
  azure_client_secret: <base64_encoded_azure_client_secret>
  azure_tenant_id: <base64_encoded_azure_tenant_id>
  azure_resource_prefix: <base64_encoded_azure_resource_prefix>
  azure_resourcegroup: <base64_encoded_azure_resourcegroup>
  azure_region: <base64_encoded_azure_region>
```

IMPORTANT

The release image includes **CredentialsRequest** objects for Technology Preview features that are enabled by the **TechPreviewNoUpgrade** feature set. You can identify these objects by their use of the **release.openshift.io/feature-gate: TechPreviewNoUpgrade** annotation.

- If you are not using any of these features, do not create secrets for these objects. Creating secrets for Technology Preview features that you are not using can cause the installation to fail.
- If you are using any of these features, you must create secrets for the corresponding objects.

- To find **CredentialsRequest** objects with the **TechPreviewNoUpgrade** annotation, run the following command:

```
$ grep "release.openshift.io/feature-gate" *
```

Example output

```
0000_30_capi-operator_00_credentials-request.yaml:  release.openshift.io/feature-gate:
TechPreviewNoUpgrade
```

7. From the directory that contains the installation program, proceed with your cluster creation:

```
$ openshift-install create cluster --dir <installation_directory>
```

IMPORTANT

Before upgrading a cluster that uses manually maintained credentials, you must ensure that the CCO is in an upgradeable state.

Additional resources

- Updating a cluster using the web console
- Updating a cluster using the CLI

6.3.3. Next steps

- Install an OpenShift Container Platform cluster:
  - Installing a cluster quickly on Azure with default options on installer-provisioned infrastructure
  - Install a cluster with cloud customizations on installer-provisioned infrastructure
  - Install a cluster with network customizations on installer-provisioned infrastructure

6.4. ENABLING USER-MANAGED ENCRYPTION FOR AZURE

In OpenShift Container Platform version 4.11, you can install a cluster with a user-managed encryption key in Azure. To enable this feature, you can prepare an Azure DiskEncryptionSet before installation, modify the **install-config.yaml** file, and then perform post-installation steps.

6.4.1. Preparing an Azure Disk Encryption Set

The OpenShift Container Platform installer can use an existing Disk Encryption Set with a user-managed key. To enable this feature, you can create a Disk Encryption Set in Azure and provide the key to the installer.

Procedure

1. Set the following environment variables for the Azure resource group by running the following command:

```
$ export RESOURCEGROUP="<resource_group>" \ 1
  LOCATION="<location>" 2
```

1. Specifies the name of the Azure resource group where you will create the Disk Encryption Set and encryption key. To avoid losing access to your keys after destroying the cluster, you should create the Disk Encryption Set in a different resource group than the resource group where you install the cluster.
2. Specifies the Azure location where you will create the resource group.

2. Set the following environment variables for the Azure Key Vault and Disk Encryption Set by running the following command:

```
$ export KEYVAULT_NAME="<keyvault_name>" \ 1
  KEYVAULT_KEY_NAME="<keyvault_key_name>" \ 2
  DISK_ENCRYPTION_SET_NAME="<disk_encryption_set_name>" 3
```

1. Specifies the name of the Azure Key Vault you will create.
2. Specifies the name of the encryption key you will create.
3. Specifies the name of the disk encryption set you will create.

3. Set the environment variable for the ID of your Azure Service Principal by running the following command:

```
$ export CLUSTER_SP_ID="<service_principal_id>" 1
```

1. Specifies the ID of the service principal you will use for this installation.

4. Enable host-level encryption in Azure by running the following commands:

```
$ az feature register --namespace "Microsoft.Compute" --name "EncryptionAtHost"
```

```
$ az feature show --namespace Microsoft.Compute --name EncryptionAtHost
```

```
$ az provider register -n Microsoft.Compute
```

5. Create an Azure Resource Group to hold the disk encryption set and associated resources by running the following command:

```
$ az group create --name $RESOURCEGROUP --location $LOCATION
```

6. Create an Azure key vault by running the following command:

```
$ az keyvault create -n $KEYVAULT_NAME -g $RESOURCEGROUP -l $LOCATION \
  --enable-purge-protection true
```

7. Create an encryption key in the key vault by running the following command:

```
$ az keyvault key create --vault-name $KEYVAULT_NAME -n $KEYVAULT_KEY_NAME \
  --protection software
```

8. Capture the ID of the key vault by running the following command:

```
$ KEYVAULT_ID=$(az keyvault show --name $KEYVAULT_NAME --query "[id]" -o tsv)
```

9. Capture the key URL in the key vault by running the following command:

```
$ KEYVAULT_KEY_URL=$(az keyvault key show --vault-name $KEYVAULT_NAME --name
\
  $KEYVAULT_KEY_NAME --query "[key.kid]" -o tsv)
```

10. Create a disk encryption set by running the following command:

```
$ az disk-encryption-set create -n $DISK_ENCRYPTION_SET_NAME -l $LOCATION -g \
  $RESOURCEGROUP --source-vault $KEYVAULT_ID --key-url $KEYVAULT_KEY_URL
```

11. Grant the DiskEncryptionSet resource access to the key vault by running the following commands:

```
$ DES_IDENTITY=$(az disk-encryption-set show -n $DISK_ENCRYPTION_SET_NAME -g \
  $RESOURCEGROUP --query "[identity.principalId]" -o tsv)
```

```
$ az keyvault set-policy -n $KEYVAULT_NAME -g $RESOURCEGROUP --object-id \
  $DES_IDENTITY --key-permissions wrapkey unwrapkey get
```

12. Grant the Azure Service Principal permission to read the DiskEncryptionSet by running the following commands:

```
$ DES_RESOURCE_ID=$(az disk-encryption-set show -n
$DISK_ENCRYPTION_SET_NAME -g \
  $RESOURCEGROUP --query "[id]" -o tsv)
```

```
$ az role assignment create --assignee $CLUSTER_SP_ID --role "<reader_role>" \ 1
  --scope $DES_RESOURCE_ID -o jsonc
```

1 Specifies an Azure role with read permissions to the disk encryption set. You can use the **Owner** role or a custom role with the necessary permissions.

6.4.2. Next steps

- Install an OpenShift Container Platform cluster:
  - Install a cluster with customizations on installer-provisioned infrastructure
  - Install a cluster with network customizations on installer-provisioned infrastructure
  - Install a cluster into an existing VNet on installer-provisioned infrastructure
  - Install a private cluster on installer-provisioned infrastructure
  - Install a cluster into an government region on installer-provisioned infrastructure

6.5. INSTALLING A CLUSTER QUICKLY ON AZURE

In OpenShift Container Platform version 4.11, you can install a cluster on Microsoft Azure that uses the default configuration options.

6.5.1. Prerequisites

- You reviewed details about the OpenShift Container Platform installation and update processes.
- You read the documentation on selecting a cluster installation method and preparing it for users.
- You configured an Azure account to host the cluster and determined the tested and validated region to deploy the cluster to.
- If you use a firewall, you configured it to allow the sites that your cluster requires access to.
- If the cloud identity and access management (IAM) APIs are not accessible in your environment, or if you do not want to store an administrator-level credential secret in the **kube-system** namespace, you can manually create and maintain IAM credentials.

6.5.2. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.11, you require access to the internet to install your cluster.

You must have internet access to:

- Access OpenShift Cluster Manager Hybrid Cloud Console to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access Quay.io to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.

IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

6.5.3. Generating a key pair for cluster node SSH access

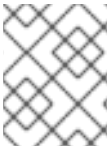
During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the **~/.ssh/authorized_keys** list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The **./openshift-install gather** command also requires the SSH public key to be in place on the cluster nodes.

IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.



NOTE

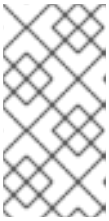
You must use a local key, not one that you configured with platform-specific approaches such as AWS key pairs.

Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N '' -f <path>/<file_name> 1
```

1 Specify the path and file name, such as **~/.ssh/id_ed25519**, of the new SSH key. If you have an existing key pair, ensure your public key is in the your **~/.ssh** directory.



NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS validated or Modules In Process cryptographic libraries on the **x86_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the ~/**.ssh/id_ed25519.pub** public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the **./openshift-install gather** command.

NOTE

On some distributions, default SSH private key identities such as ~/**.ssh/id_rsa** and ~/**.ssh/id_dsa** are managed automatically.

a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

Example output

```
Agent pid 31874
```

NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

1 Specify the path and file name for your SSH private key, such as ~/**.ssh/id_ed25519**

Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

6.5.4. Obtaining the installation program

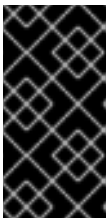
Before you install OpenShift Container Platform, download the installation file on a local computer.

Prerequisites

- You have a computer that runs Linux or macOS, with 500 MB of local disk space.

Procedure

1. Access the Infrastructure Provider page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program that corresponds with your host operating system and architecture, and place the file in the directory where you will store the installation configuration files.



IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.

IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation pull secret from the Red Hat OpenShift Cluster Manager . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

6.5.5. Deploying the cluster

You can install OpenShift Container Platform on a compatible cloud platform.

IMPORTANT

You can run the **create cluster** command of the installation program only once, during initial installation.

Prerequisites

- Configure an account with the cloud platform that hosts your cluster.
- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.

Procedure

1. Change to the directory that contains the installation program and initialize the cluster deployment:

```
$ ./openshift-install create cluster --dir <installation_directory> \ 1
    --log-level=info 2
```

1 For **<installation_directory>**, specify the directory name to store the files that the installation program creates.

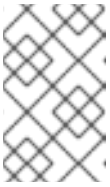
2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

When specifying the directory:

- Verify that the directory has the **execute** permission. This permission is required to run Terraform binaries under the installation directory.
- Use an empty directory. Some installation assets, such as bootstrap X.509 certificates, have short expiration intervals, therefore you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

2. Provide values at the prompts:

   a. Optional: Select an SSH key to use to access your cluster machines.



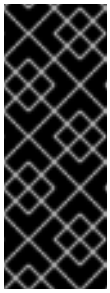
NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

   b. Select **azure** as the platform to target.

   c. If the installation program cannot locate the **osServicePrincipal.json** configuration file, which contains Microsoft Azure profile information, in the ~/**.azure**/ directory on your computer, the installer prompts you to specify the following Azure parameter values for your subscription and service principal.

      - **azure subscription id** The subscription ID to use for the cluster. Specify the **id** value in your account output.
      - **azure tenant id** The tenant ID. Specify the **tenantId** value in your account output.
      - **azure service principal client id** The value of the **appId** parameter for the service principal.
      - **azure service principal client secret** The value of the **password** parameter for the service principal.



IMPORTANT

After you enter values for the previously listed parameters, the installation program creates a **osServicePrincipal.json** configuration file and stores this file in the ~/**.azure**/ directory on your computer. These actions ensure that the installation program can load the profile when it is creating an OpenShift Container Platform cluster on the target platform.

d. Select the region to deploy the cluster to.

e. Select the base domain to deploy the cluster to. The base domain corresponds to the Azure DNS Zone that you created for your cluster.

f. Enter a descriptive name for your cluster.

IMPORTANT

All Azure resources that are available through public endpoints are subject to resource name restrictions, and you cannot create resources that use certain terms. For a list of terms that Azure restricts, see Resolve reserved resource name errors in the Azure documentation.

g. Paste the pull secret from the Red Hat OpenShift Cluster Manager .

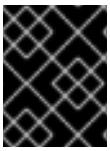
NOTE

If the cloud provider account that you configured on your host does not have sufficient permissions to deploy the cluster, the installation process stops, and the missing permissions are displayed.

Verification

When the cluster deployment completes successfully:

- The terminal displays directions for accessing your cluster, including a link to the web console and credentials for the **kubeadmin** user.
- Credential information also outputs to **<installation_directory>/.openshift_install.log**.



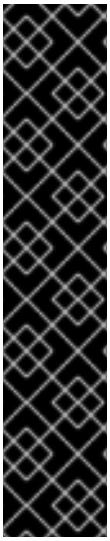
IMPORTANT

Do not delete the installation program or the files that the installation program creates. Both are required to delete the cluster.

Example output

```
...
INFO Install complete!
INFO To access the cluster as the system:admin user when using 'oc', run 'export
KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
INFO Access the OpenShift web-console here: https://console-openshift-
```

```
console.apps.mycluster.example.com
INFO Login to the console with user: "kubeadmin", and password: "password"
INFO Time elapsed: 36m22s
```



IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

6.5.6. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.

IMPORTANT

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.11. Download and install the new version of **oc**.

Installing the OpenShift CLI on Linux
You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the architecture in the **Product Variant** drop-down menu.
3. Select the appropriate version in the **Version** drop-down menu.
4. Click **Download Now** next to the **OpenShift v4.11 Linux Client** entry and save the file.
5. Unpack the archive:

   ```
   $ tar xvf <file>
   ```

6. Place the **oc** binary in a directory that is on your **PATH**.
   To check your **PATH**, execute the following command:

   ```
   $ echo $PATH
   ```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.
   To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
C:\> oc <command>
```

Installing the OpenShift CLI on macOS

You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 macOS Client** entry and save the file.

NOTE

For macOS arm64, choose the **OpenShift v4.11 macOS arm64 Client** entry.

4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your PATH.
   To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

6.5.7. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

Example output

```
system:admin
```

Additional resources

- See Accessing the web console for more details about accessing and understanding the OpenShift Container Platform web console.

6.5.8. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.11, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to OpenShift Cluster Manager Hybrid Cloud Console.

After you confirm that your OpenShift Cluster Manager Hybrid Cloud Console inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, use subscription watch to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

Additional resources

- See About remote health monitoring for more information about the Telemetry service

6.5.9. Next steps

- Customize your cluster.
- If necessary, you can opt out of remote health reporting .

6.6. INSTALLING A CLUSTER ON AZURE WITH CUSTOMIZATIONS

In OpenShift Container Platform version 4.11, you can install a customized cluster on infrastructure that the installation program provisions on Microsoft Azure. To customize the installation, you modify parameters in the **install-config.yaml** file before you install the cluster.

6.6.1. Prerequisites

- You reviewed details about the OpenShift Container Platform installation and update processes.
- You read the documentation on selecting a cluster installation method and preparing it for users.
- You configured an Azure account to host the cluster and determined the tested and validated region to deploy the cluster to.
- If you use a firewall, you configured it to allow the sites that your cluster requires access to.
- If the cloud identity and access management (IAM) APIs are not accessible in your environment, or if you do not want to store an administrator-level credential secret in the **kube-system** namespace, you can manually create and maintain IAM credentials.
- If you use customer-managed encryption keys, you prepared your Azure environment for encryption.

6.6.2. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.11, you require access to the internet to install your cluster.

You must have internet access to:

- Access OpenShift Cluster Manager Hybrid Cloud Console to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access Quay.io to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.

IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

6.6.3. Generating a key pair for cluster node SSH access

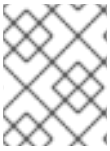
During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the **~/.ssh/authorized_keys** list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The **./openshift-install gather** command also requires the SSH public key to be in place on the cluster nodes.

IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.



NOTE

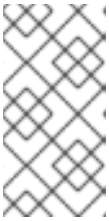
You must use a local key, not one that you configured with platform-specific approaches such as AWS key pairs.

Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N '' -f <path>/<file_name>
```
(1)

(1) Specify the path and file name, such as **~/.ssh/id_ed25519**, of the new SSH key. If you have an existing key pair, ensure your public key is in the your **~/.ssh** directory.



NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS validated or Modules In Process cryptographic libraries on the **x86_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the ~/**.ssh/id_ed25519.pub** public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the **./openshift-install gather** command.

NOTE

On some distributions, default SSH private key identities such as ~/**.ssh/id_rsa** and ~/**.ssh/id_dsa** are managed automatically.

a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

Example output

```
Agent pid 31874
```

NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

1 Specify the path and file name for your SSH private key, such as ~/**.ssh/id_ed25519**

Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

6.6.4. Selecting an Azure Marketplace image

If you are deploying an OpenShift Container Platform cluster using the Azure Marketplace offering, you must first obtain the Azure Marketplace image. The installation program uses this image to deploy worker nodes. When obtaining your image, consider the following:

- While the images are the same, the Azure Marketplace publisher is different depending on your region. If you are located in North America, specify **redhat** as the publisher. If you are located in EMEA, specify **redhat-limited** as the publisher.
- The offer includes a **rh-ocp-worker** SKU and a **rh-ocp-worker-gen1** SKU. The **rh-ocp-worker** SKU represents a Hyper-V generation version 2 VM image. The default instance types used in OpenShift Container Platform are version 2 compatible. If you are going to use an instance type that is only version 1 compatible, use the image associated with the **rh-ocp-worker-gen1** SKU. The **rh-ocp-worker-gen1** SKU represents a Hyper-V version 1 VM image.

Prerequisites

- You have installed the Azure CLI client **(az)**.
- Your Azure account is entitled for the offer and you have logged into this account with the Azure CLI client.

Procedure

1. Display all of the available OpenShift Container Platform images by running one of the following commands:
   - North America:

     ```
     $ az vm image list --all --offer rh-ocp-worker --publisher redhat -o table
     ```

     Example output

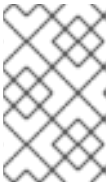
     ```
     Offer          Publisher       Sku                 Urn                                                                  Version
     -------------  --------------  ------------------  -------------------------------------------------------------------  -------
     rh-ocp-worker  RedHat          rh-ocp-worker       RedHat:rh-ocp-worker:rh-ocpworker:4.8.2021122100                     4.8.2021122100
     rh-ocp-worker  RedHat          rh-ocp-worker-gen1  RedHat:rh-ocp-worker:rh-ocp-worker-gen1:4.8.2021122100               4.8.2021122100
     ```

   - EMEA:

     ```
     $ az vm image list --all --offer rh-ocp-worker --publisher redhat-limited -o table
     ```

     Example output

     ```
     Offer          Publisher       Sku                 Urn                                                                  Version
     -------------  --------------  ------------------  -------------------------------------------------------------------  -------
     rh-ocp-worker  redhat-limited  rh-ocp-worker       redhat-limited:rh-ocp-worker:rh-ocp-worker:4.8.2021122100            4.8.2021122100
     rh-ocp-worker  redhat-limited  rh-ocp-worker-gen1  redhat-limited:rh-ocp-worker:rh-ocp-worker-gen1:4.8.2021122100       4.8.2021122100
     ```



NOTE

Regardless of the version of OpenShift Container Platform you are installing, the correct version of the Azure Marketplace image to use is 4.8.x. If required, as part of the installation process, your VMs are automatically upgraded.

2. Inspect the image for your offer by running one of the following commands:
   - North America:

     ```
     $ az vm image show --urn redhat:rh-ocp-worker:rh-ocp-worker:<version>
     ```

   - EMEA:

     ```
     $ az vm image show --urn redhat-limited:rh-ocp-worker:rh-ocp-worker:<version>
     ```

3. Review the terms of the offer by running one of the following commands:
   - North America:

     ```
     $ az vm image terms show --urn redhat:rh-ocp-worker:rh-ocp-worker:<version>
     ```

   - EMEA:

     ```
     $ az vm image terms show --urn redhat-limited:rh-ocp-worker:rh-ocp-worker:<version>
     ```

4. Accept the terms of the offering by running one of the following commands:
   - North America:

     ```
     $ az vm image terms accept --urn redhat:rh-ocp-worker:rh-ocp-worker:<version>
     ```

   - EMEA:

     ```
     $ az vm image terms accept --urn redhat-limited:rh-ocp-worker:rh-ocp-worker:<version>
     ```

5. Record the image details of your offer. You must update the **compute** section in the **install-config.yaml** file with values for **publisher**, **offer**, **sku**, and **version** before deploying the cluster.

Sample **install-config.yaml** file with the Azure Marketplace worker nodes

```
apiVersion: v1
baseDomain: example.com
compute:
- hyperthreading: Enabled
  name: worker
  platform:
    azure:
      type: Standard_D4s_v5
      osImage:
        publisher: redhat
        offer: rh-ocp-worker
```

```
      sku: rh-ocp-worker
      version: 4.8.2021122100
replicas: 3
```

6.6.5. Obtaining the installation program

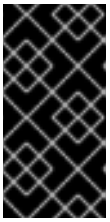
Before you install OpenShift Container Platform, download the installation file on a local computer.

Prerequisites

- You have a computer that runs Linux or macOS, with 500 MB of local disk space.

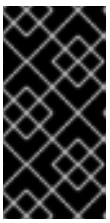
Procedure

1. Access the Infrastructure Provider page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program that corresponds with your host operating system and architecture, and place the file in the directory where you will store the installation configuration files.



IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.



IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation pull secret from the Red Hat OpenShift Cluster Manager . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

6.6.6. Creating the installation configuration file

You can customize the OpenShift Container Platform cluster you install on Microsoft Azure.

Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.
- Obtain service principal permissions at the subscription level.

Procedure

1. Create the **install-config.yaml** file.
   a. Change to the directory that contains the installation program and run the following command:

```
$ ./openshift-install create install-config --dir <installation_directory> 1
```

   1 For **<installation_directory>**, specify the directory name to store the files that the installation program creates.

   When specifying the directory:

   - Verify that the directory has the **execute** permission. This permission is required to run Terraform binaries under the installation directory.
   - Use an empty directory. Some installation assets, such as bootstrap X.509 certificates, have short expiration intervals, therefore you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

   b. At the prompts, provide the configuration details for your cloud:
      i. Optional: Select an SSH key to use to access your cluster machines.

NOTE

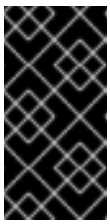
For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

      ii. Select **azure** as the platform to target.
      iii. If you do not have a Microsoft Azure profile stored on your computer, specify the following Azure parameter values for your subscription and service principal:
         - **azure subscription id** The subscription ID to use for the cluster. Specify the **id** value in your account output.
         - **azure tenant id** The tenant ID. Specify the **tenantId** value in your account output.
         - **azure service principal client id** The value of the **appId** parameter for the service principal.
         - **azure service principal client secret** The value of the **password** parameter for the service principal.

iv. Select the region to deploy the cluster to.

v. Select the base domain to deploy the cluster to. The base domain corresponds to the Azure DNS Zone that you created for your cluster.

vi. Enter a descriptive name for your cluster.



IMPORTANT

All Azure resources that are available through public endpoints are subject to resource name restrictions, and you cannot create resources that use certain terms. For a list of terms that Azure restricts, see Resolve reserved resource name errors in the Azure documentation.

vii. Paste the pull secret from the Red Hat OpenShift Cluster Manager .

2. Modify the **install-config.yaml** file. You can find more information about the available parameters in the "Installation configuration parameters" section.

3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.

IMPORTANT

The **install-config.yaml** file is consumed during the installation process. If you want to reuse the file, you must back it up now.

6.6.6.1. Installation configuration parameters

Before you deploy an OpenShift Container Platform cluster, you provide parameter values to describe your account on the cloud platform that hosts your cluster and optionally customize your cluster's platform. When you create the **install-config.yaml** installation configuration file, you provide values for the required parameters through the command line. If you customize your cluster, you can modify the **install-config.yaml** file to provide more details about the platform.

NOTE

After installation, you cannot modify these parameters in the **install-config.yaml** file.

6.6.6.1.1. Required configuration parameters

Required installation configuration parameters are described in the following table:

Table 6.1. Required parameters

Parameter	Description	Values
apiVersion	The API version for the **install-config.yaml** content. The current version is **v1**. The installer may also support older API versions.	String

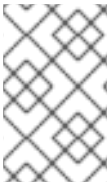
Parameter	Description	Values
baseDomain	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the **baseDomain** and **metadata.name** parameter values that uses the **<metadata.name>.<baseDomain>** format.	A fully-qualified domain or subdomain name, such as **example.com**.
metadata	Kubernetes resource **ObjectMeta**, from which only the **name** parameter is consumed.	Object
metadata.name	The name of the cluster. DNS records for the cluster are all subdomains of **{{.metadata.name}}.{{.baseDomain}}**.	String of lowercase letters, hyphens (**-**), and periods (**.**), such as **dev**.
platform	The configuration for the specific platform upon which to perform the installation: **alibabacloud**, **aws**, **baremetal**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**. For additional information about **platform.<platform>** parameters, consult the table for your specific platform that follows.	Object

Parameter	Description	Values
pullSecret	Get a pull secret from the Red Hat OpenShift Cluster Manager to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	<pre>{ "auths":{ "cloud.openshift.com":{ "auth":"b3Blb=", "email":"you@example.com" }, "quay.io":{ "auth":"b3Blb=", "email":"you@example.com" } } }</pre>

6.6.6.1.2. Network configuration parameters

You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

Only IPv4 addresses are supported.



NOTE

Globalnet is not supported with Red Hat OpenShift Data Foundation disaster recovery solutions. For regional disaster recovery scenarios, ensure that you use a nonoverlapping range of private IP addresses for the cluster and service networks in each cluster.

Table 6.2. Network parameters

Parameter	Description	Values
networking	The configuration for the cluster network.	Object  **NOTE** You cannot modify parameters specified by the **networking** object after installation.

Parameter	Description	Values
networking.networkType	The cluster network provider Container Network Interface (CNI) cluster network provider to install.	Either **OpenShiftSDN** or **OVNKubernetes**. **OpenShiftSDN** is a CNI provider for all-Linux networks. **OVNKubernetes** is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is **OpenShiftSDN**.
networking.clusterNetwork	The IP address blocks for pods. The default value is **10.128.0.0/14** with a host prefix of **/23**. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: `networking:` `  clusterNetwork:` `  - cidr: 10.128.0.0/14` `    hostPrefix: 23`
networking.clusterNetwork.cidr	Required if you use **networking.clusterNetwork**. An IP address block. An IPv4 network.	An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between **0** and **32**.
networking.clusterNetwork.hostPrefix	The subnet prefix length to assign to each individual node. For example, if **hostPrefix** is set to **23** then each node is assigned a **/23** subnet out of the given **cidr**. A **hostPrefix** value of **23** provides 510 (2^(32 - 23) - 2) pod IP addresses.	A subnet prefix. The default value is **23**.
networking.serviceNetwork	The IP address block for services. The default value is **172.30.0.0/16**. The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.	An array with an IP address block in CIDR format. For example: `networking:` `  serviceNetwork:` `  - 172.30.0.0/16`
networking.machineNetwork	The IP address blocks for machines. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: `networking:` `  machineNetwork:` `  - cidr: 10.0.0.0/16`

Parameter	Description	Values
networking.machineNetwork.cidr	Required if you use **networking.machineNetwork**. An IP address block. The default value is **10.0.0.0/16** for all platforms other than libvirt. For libvirt, the default value is **192.168.126.0/24**.	An IP network block in CIDR notation. For example, **10.0.0.0/16**.  **NOTE** Set the **networking.machineNetwork** to match the CIDR that the preferred NIC resides in.

6.6.6.1.3. Optional configuration parameters

Optional installation configuration parameters are described in the following table:

Table 6.3. Optional parameters

Parameter	Description	Values
additionalTrustBundle	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String
capabilities	Controls the installation of optional core cluster components. You can reduce the footprint of your OpenShift Container Platform cluster by disabling optional components.	String array
capabilities.baselineCapabilitySet	Selects an initial set of optional capabilities to enable. Valid values are **None**, **v4.11** and **vCurrent**. **v4.11** enables the **baremetal** Operator, the **marketplace** Operator, and the **openshift-samples** content. **vCurrent** installs the recommended set of capabilities for the current version of OpenShift Container Platform. The default value is **vCurrent**.	String

Parameter	Description	Values
capabilities.additionalEnabledCapabilities	Extends the set of optional capabilities beyond what you specify in **baselineCapabilitySet**. Valid values are **baremetal**, **marketplace** and **openshift-samples**. You may specify multiple capabilities in this parameter.	String array
cgroupsV2	Enables Linux control groups version 2 (cgroups v2) on specific nodes in your cluster. The OpenShift Container Platform process for enabling cgroups v2 disables all cgroup version 1 controllers and hierarchies. The OpenShift Container Platform cgroups version 2 feature is in Developer Preview and is not supported by Red Hat at this time.	**true**
compute	The configuration for the machines that comprise the compute nodes.	Array of **MachinePool** objects.
compute.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** (the default).	String
compute.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  IMPORTANT If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
compute.name	Required if you use **compute**. The name of the machine pool.	**worker**

Parameter	Description	Values
compute.platform	Required if you use **compute**. Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the **controlPlane.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
compute.replicas	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to **2**. The default value is **3**.
controlPlane	The configuration for the machines that comprise the control plane.	Array of **MachinePool** objects.
controlPlane.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** (the default).	String
controlPlane.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  IMPORTANT If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
controlPlane.name	Required if you use **controlPlane**. The name of the machine pool.	**master**

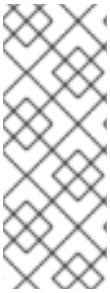
Parameter	Description	Values
controlPlane.platform	Required if you use **controlPlane**. Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the **compute.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
controlPlane.replicas	The number of control plane machines to provision.	The only supported value is **3**, which is the default value.
credentialsMode	The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported.  **NOTE** Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the *Cloud Credential Operator* entry in the *Cluster Operators reference* content.  **NOTE** If your AWS account has service control policies (SCP) enabled, you must configure the **credentialsMode** parameter to **Mint**, **Passthrough** or **Manual**.	**Mint**, **Passthrough**, **Manual** or an empty string (**""**).

Parameter	Description	Values
fips	Enable or disable FIPS mode. The default is **false** (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.  **IMPORTANT** To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.  **NOTE** If you are using Azure File storage, you cannot enable FIPS mode.	**false** or **true**
imageContentSources	Sources and repositories for the release-image content.	Array of objects. Includes a **source** and, optionally, **mirrors**, as described in the following rows of this table.
imageContentSources.source	Required if you use **imageContentSources**. Specify the repository that users refer to, for example, in image pull specifications.	String

Parameter	Description	Values
imageContentSources.mirrors	Specify one or more repositories that may also contain the same images.	Array of strings
publish	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	**Internal** or **External**. To deploy a private cluster, which cannot be accessed from the internet, set **publish** to **Internal**. The default value is **External**.
sshKey	The SSH key to authenticate access to your cluster machines.  **NOTE** For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.	For example, **sshKey: ssh-ed25519 AAAA..**.

6.6.6.1.4. Additional Azure configuration parameters

Additional Azure configuration parameters are described in the following table.



NOTE

By default, if you specify availability zones in the **install-config.yaml** file, the installation program distributes the control plane machines and the compute machines across these availability zones within a region. To ensure high availability for your cluster, select a region with at least three availability zones. If your region contains fewer than three availability zones, the installation program places more than one control plane machine in the available zones.

Table 6.4. Additional Azure parameters

Parameter	Description	Values

Parameter	Description	Values
compute.platform.azure.encryptionAtHost	Enables host-level encryption for compute machines. You can enable this encryption alongside user-managed server-side encryption. This feature encrypts temporary, ephemeral, cached and un-managed disks on the VM host. This is not a prerequisite for user-managed server-side encryption.	**true** or **false**. The default is **false**.
compute.platform.azure.osDisk.diskSizeGB	The Azure disk size for the VM.	Integer that represents the size of the disk in GB. The default is **128**.
compute.platform.azure.osDisk.diskType	Defines the type of disk.	**standard_LRS**, **premium_LRS**, or **standardSSD_LRS**. The default is **premium_LRS**.
compute.platform.azure.ultraSSDCapability	Enables the use of Azure ultra disks for persistent storage on compute nodes. This requires that your Azure region and zone have ultra disks available.	**Enabled**, **Disabled**. The default is **Disabled**.
compute.platform.azure.osDisk.diskEncryptionSet.resourceGroup	The name of the Azure resource group that contains the disk encryption set from the installation prerequisites. This resource group should be different than the resource group where you install the cluster to avoid deleting your Azure encryption key when the cluster is destroyed. This value is only necessary if you intend to install the cluster with user-managed disk encryption.	String, for example **production_encryption_resource_group**.
compute.platform.azure.osDisk.diskEncryptionSet.name	The name of the disk encryption set that contains the encryption key from the installation prerequisites.	String, for example **production_disk_encryption_set**.
compute.platform.azure.osDisk.diskEncryptionSet.subscriptionId	Defines the Azure subscription of the disk encryption set where the disk encryption set resides. This secondary disk encryption set is used to encrypt compute machines.	String, in the format **00000000-0000-0000-0000-000000000000**.

Parameter	Description	Values
compute.platform.azure.vmNetworkingType	Enables accelerated networking. Accelerated networking enables single root I/O virtualization (SR-IOV) to a VM, improving its networking performance. If instance type of compute machines support **Accelerated** networking, by default, the installer enables **Accelerated** networking, otherwise the default networking type is **Basic**.	**Accelerated** or **Basic**.
compute.platform.azure.type	Defines the Azure instance type for compute machines.	String
compute.platform.azure.zones	The availability zones where the installation program creates compute machines.	String list
controlPlane.platform.azure.type	Defines the Azure instance type for control plane machines.	String
controlPlane.platform.azure.zones	The availability zones where the installation program creates control plane machines.	String list
platform.azure.defaultMachinePlatform.encryptionAtHost	Enables host-level encryption for compute machines. You can enable this encryption alongside user-managed server-side encryption. This feature encrypts temporary, ephemeral, cached, and un-managed disks on the VM host. This parameter is not a prerequisite for user-managed server-side encryption.	**true** or **false**. The default is **false**.
platform.azure.defaultMachinePlatform.osDisk.diskEncryptionSet.name	The name of the disk encryption set that contains the encryption key from the installation prerequisites.	String, for example, **production_disk_encryption_set**.
platform.azure.defaultMachinePlatform.osDisk.diskEncryptionSet.resourceGroup	The name of the Azure resource group that contains the disk encryption set from the installation prerequisites. To avoid deleting your Azure encryption key when the cluster is destroyed, this resource group must be different from the resource group where you install the cluster. This value is necessary only if you intend to install the cluster with user-managed disk encryption.	String, for example, **production_encryption_resource_group**.

Parameter	Description	Values
platform.azure.defaultMachinePlatform.osDisk.diskEncryptionSet.subscriptionId	Defines the Azure subscription of the disk encryption set where the disk encryption set resides. This secondary disk encryption set is used to encrypt compute machines.	String, in the format **00000000-0000-0000-0000-000000000000**.
platform.azure.defaultMachinePlatform.osDisk.diskSizeGB	The Azure disk size for the VM.	Integer that represents the size of the disk in GB. The default is **128**.
platform.azure.defaultMachinePlatform.osDisk.diskType	Defines the type of disk.	**premium_LRS** or **standardSSD_LRS**. The default is **premium_LRS**.
platform.azure.defaultMachinePlatform.type	The Azure instance type for control plane and compute machines.	The Azure instance type.
platform.azure.defaultMachinePlatform.zones	The availability zones where the installation program creates compute and control plane machines.	String list.
controlPlane.platform.azure.encryptionAtHost	Enables host-level encryption for control plane machines. You can enable this encryption alongside user-managed server-side encryption. This feature encrypts temporary, ephemeral, cached and un-managed disks on the VM host. This is not a prerequisite for user-managed server-side encryption.	**true** or **false**. The default is **false**.
controlPlane.platform.azure.osDisk.diskEncryptionSet.resourceGroup	The name of the Azure resource group that contains the disk encryption set from the installation prerequisites. This resource group should be different than the resource group where you install the cluster to avoid deleting your Azure encryption key when the cluster is destroyed. This value is only necessary if you intend to install the cluster with user-managed disk encryption.	String, for example **production_encryption_resource_group**.
controlPlane.platform.azure.osDisk.diskEncryptionSet.name	The name of the disk encryption set that contains the encryption key from the installation prerequisites.	String, for example **production_disk_encryption_set**.

Parameter	Description	Values
controlPlane.platform.azure.osDisk.diskEncryptionSet.subscriptionId	Defines the Azure subscription of the disk encryption set where the disk encryption set resides. This secondary disk encryption set is used to encrypt control plane machines.	String, in the format **00000000-0000-0000-0000-000000000000**.
controlPlane.platform.azure.osDisk.diskSizeGB	The Azure disk size for the VM.	Integer that represents the size of the disk in GB. The default is **1024**.
controlPlane.platform.azure.osDisk.diskType	Defines the type of disk.	**premium_LRS** or **standardSSD_LRS**. The default is **premium_LRS**.
controlPlane.platform.azure.ultraSSDCapability	Enables the use of Azure ultra disks for persistent storage on control plane machines. This requires that your Azure region and zone have ultra disks available.	**Enabled**, **Disabled**. The default is **Disabled**.
controlPlane.platform.azure.vmNetworkingType	Enables accelerated networking. Accelerated networking enables single root I/O virtualization (SR-IOV) to a VM, improving its networking performance. If instance type of control plane machines support **Accelerated** networking, by default, the installer enables **Accelerated** networking, otherwise the default networking type is **Basic**.	**Accelerated** or **Basic**.
platform.azure.baseDomainResourceGroupName	The name of the resource group that contains the DNS zone for your base domain.	String, for example **production_cluster**.

Parameter	Description	Values
platform.azure.resourceGroupName	The name of an already existing resource group to install your cluster to. This resource group must be empty and only used for this specific cluster; the cluster components assume ownership of all resources in the resource group. If you limit the service principal scope of the installation program to this resource group, you must ensure all other resources used by the installation program in your environment have the necessary permissions, such as the public DNS zone and virtual network. Destroying the cluster by using the installation program deletes this resource group.	String, for example **existing_resource_group**.
platform.azure.outboundType	The outbound routing strategy used to connect your cluster to the internet. If you are using user-defined routing, you must have pre-existing networking available where the outbound routing has already been configured prior to installing a cluster. The installation program is not responsible for configuring user-defined routing.	**LoadBalancer** or **UserDefinedRouting**. The default is **LoadBalancer**.
platform.azure.region	The name of the Azure region that hosts your cluster.	Any valid region name, such as **centralus**.
platform.azure.zone	List of availability zones to place machines in. For high availability, specify at least two zones.	List of zones, for example **["1", "2", "3"]**.
platform.azure.defaultMachinePlatform.ultraSSDCapability	Enables the use of Azure ultra disks for persistent storage on control plane and compute machines. This requires that your Azure region and zone have ultra disks available.	**Enabled**, **Disabled**. The default is **Disabled**.
platform.azure.networkResourceGroupName	The name of the resource group that contains the existing VNet that you want to deploy your cluster to. This name cannot be the same as the **platform.azure.baseDomainResourceGroupName**.	String.
platform.azure.virtualNetwork	The name of the existing VNet that you want to deploy your cluster to.	String.

Parameter	Description	Values
platform.azure.controlPlaneSubnet	The name of the existing subnet in your VNet that you want to deploy your control plane machines to.	Valid CIDR, for example **10.0.0.0/16**.
platform.azure.computeSubnet	The name of the existing subnet in your VNet that you want to deploy your compute machines to.	Valid CIDR, for example **10.0.0.0/16**.
platform.azure.cloudName	The name of the Azure cloud environment that is used to configure the Azure SDK with the appropriate Azure API endpoints. If empty, the default value **AzurePublicCloud** is used.	Any valid cloud environment, such as **AzurePublicCloud** or **AzureUSGovernmentCloud**.
platform.azure.defaultMachinePlatform.vmNetworkingType	Enables accelerated networking. Accelerated networking enables single root I/O virtualization (SR-IOV) to a VM, improving its networking performance.	**Accelerated** or **Basic**. If instance type of control plane and compute machines support **Accelerated** networking, by default, the installer enables **Accelerated** networking, otherwise the default networking type is **Basic**.

NOTE

You cannot customize Azure Availability Zones or Use tags to organize your Azure resources with an Azure cluster.

6.6.6.2. Minimum resource requirements for cluster installation

Each cluster machine must meet the following minimum requirements:

Table 6.5. Minimum resource requirements

Machine	Operating System	vCPU [1]	Virtual RAM	Storage	IOPS [2]
Bootstrap	RHCOS	4	16 GB	100 GB	300
Control plane	RHCOS	4	16 GB	100 GB	300
Compute	RHCOS, RHEL 8.6 and later [3]	2	8 GB	100 GB	300

1. One vCPU is equivalent to one physical core when simultaneous multithreading (SMT), or hyperthreading, is not enabled. When enabled, use the following formula to calculate the corresponding ratio: (threads per core × cores) × sockets = vCPUs.

2. OpenShift Container Platform and Kubernetes are sensitive to disk performance, and faster storage is recommended, particularly for etcd on the control plane nodes which require a 10 ms p99 fsync duration. Note that on many cloud platforms, storage size and IOPS scale together, so you might need to over-allocate storage volume to obtain sufficient performance.

3. As with all user-provisioned installations, if you choose to use RHEL compute machines in your cluster, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks. Use of RHEL 7 compute machines is deprecated and has been removed in OpenShift Container Platform 4.10 and later.

IMPORTANT

You are required to use Azure virtual machines that have the **premiumIO** parameter set to **true**.

If an instance type for your platform meets the minimum requirements for cluster machines, it is supported to use in OpenShift Container Platform.

Additional resources

- Optimizing storage

6.6.6.3. Tested instance types for Azure

The following Microsoft Azure instance types have been tested with OpenShift Container Platform.

Example 6.1. Machine types

- **c4.***
- **c5.***
- **c5a.***
- **i3.***
- **m4.***
- **m5.***
- **m5a.***
- **m6a.***
- **m6i.***
- **r4.***
- **r5.***
- **r5a.***
- **r6i.***
- **t3.***

- **t3a.***

6.6.6.4. Sample customized install-config.yaml file for Azure

You can customize the **install-config.yaml** file to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.

IMPORTANT

This sample YAML file is provided for reference only. You must obtain your **install-config.yaml** file by using the installation program and modify it.

```
apiVersion: v1
baseDomain: example.com (1)
controlPlane: (2)
  hyperthreading: Enabled (3) (4)
  name: master
  platform:
    azure:
      encryptionAtHost: true
      ultraSSDCapability: Enabled
      osDisk:
        diskSizeGB: 1024 (5)
        diskType: Premium_LRS
        diskEncryptionSet:
          resourceGroup: disk_encryption_set_resource_group
          name: disk_encryption_set_name
          subscriptionId: secondary_subscription_id
      type: Standard_D8s_v3
  replicas: 3
compute: (6)
- hyperthreading: Enabled (7)
  name: worker
  platform:
    azure:
      ultraSSDCapability: Enabled
      type: Standard_D2s_v3
      encryptionAtHost: true
      osDisk:
        diskSizeGB: 512 (8)
        diskType: Standard_LRS
        diskEncryptionSet:
          resourceGroup: disk_encryption_set_resource_group
          name: disk_encryption_set_name
          subscriptionId: secondary_subscription_id
      zones: (9)
      - "1"
      - "2"
      - "3"
  replicas: 5
metadata:
  name: test-cluster (10)
```

```
networking:
  clusterNetwork:
  - cidr: 10.128.0.0/14
    hostPrefix: 23
  machineNetwork:
  - cidr: 10.0.0.0/16
  networkType: OpenShiftSDN
  serviceNetwork:
  - 172.30.0.0/16
platform:
  azure:
    defaultMachinePlatform:
      ultraSSDCapability: Enabled
    baseDomainResourceGroupName: resource_group 11
    region: centralus 12
    resourceGroupName: existing_resource_group 13
    outboundType: Loadbalancer
    cloudName: AzurePublicCloud
pullSecret: '{"auths": ...}' 14
fips: false 15
sshKey: ssh-ed25519 AAAA... 16
```

1 10 12 14 Required. The installation program prompts you for this value.

2 6 If you do not provide these parameters and values, the installation program provides the default value.

3 7 The **controlPlane** section is a single mapping, but the **compute** section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, **-**, and the first line of the **controlPlane** section must not. Only one control plane pool is used.

4 Whether to enable or disable simultaneous multithreading, or **hyperthreading**. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores. You can disable it by setting the parameter value to **Disabled**. If you disable simultaneous multithreading in some cluster machines, you must disable it in all cluster machines.

IMPORTANT

If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance. Use larger virtual machine types, such as **Standard_D8s_v3**, for your machines if you disable simultaneous multithreading.

5 8 You can specify the size of the disk to use in GB. Minimum recommendation for control plane nodes is 1024 GB.

9 Specify a list of zones to deploy your machines to. For high availability, specify at least two zones.

11 Specify the name of the resource group that contains the DNS zone for your base domain.

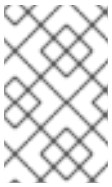
13 Specify the name of an already existing resource group to install your cluster to. If undefined, a new resource group is created for the cluster.

15 Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is

IMPORTANT

To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.

16 You can optionally provide the **sshKey** value that you use to access the machines in your cluster.



NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

6.6.6.5. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.

NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
```

```
additionalTrustBundle: | 4
  -----BEGIN CERTIFICATE-----
  <MY_TRUSTED_CA_CERT>
  -----END CERTIFICATE-----
```

1. A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
2. A proxy URL to use for creating HTTPS connections outside the cluster.
3. A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use * to bypass the proxy for all destinations.
4. If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace that contains one or more additional CA certificates that are required for proxying HTTPS connections. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges these contents with the Red Hat Enterprise Linux CoreOS (RHCOS) trust bundle, and this config map is referenced in the **trustedCA** field of the **Proxy** object. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.

NOTE

The installation program does not support the proxy **readinessEndpoints** field.

NOTE

If the installer times out, restart and then complete the deployment by using the **wait-for** command of the installer. For example:

```
$ ./openshift-install wait-for install-complete --log-level debug
```

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.

NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

Additional resources

- For more details about Accelerated Networking, see Accelerated Networking for Microsoft Azure VMs.

6.6.7. Deploying the cluster

You can install OpenShift Container Platform on a compatible cloud platform.

IMPORTANT

You can run the **create cluster** command of the installation program only once, during initial installation.

Prerequisites

- Configure an account with the cloud platform that hosts your cluster.
- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.

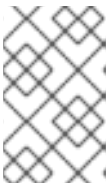
Procedure

- Change to the directory that contains the installation program and initialize the cluster deployment:

```
$ ./openshift-install create cluster --dir <installation_directory> \ 1
    --log-level=info 2
```

1 For **<installation_directory>**, specify the location of your customized **./install-config.yaml** file.

2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.



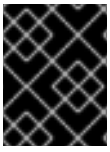
NOTE

If the cloud provider account that you configured on your host does not have sufficient permissions to deploy the cluster, the installation process stops, and the missing permissions are displayed.

Verification

When the cluster deployment completes successfully:

- The terminal displays directions for accessing your cluster, including a link to the web console and credentials for the **kubeadmin** user.
- Credential information also outputs to **<installation_directory>/.openshift_install.log**.



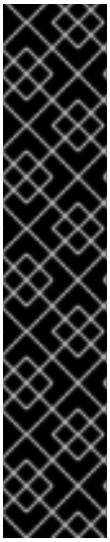
IMPORTANT

Do not delete the installation program or the files that the installation program creates. Both are required to delete the cluster.

Example output

```
...
INFO Install complete!
INFO To access the cluster as the system:admin user when using 'oc', run 'export
KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
INFO Access the OpenShift web-console here: https://console-openshift-
```

```
console.apps.mycluster.example.com
INFO Login to the console with user: "kubeadmin", and password: "password"
INFO Time elapsed: 36m22s
```



IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

6.6.8. Finalizing user-managed encryption after installation

If you installed OpenShift Container Platform using a user-managed encryption key, you can complete the installation by creating a new storage class and granting write permissions to the Azure cluster resource group.

Procedure

1. Obtain the identity of the cluster resource group used by the installer:
   a. If you specified an existing resource group in **install-config.yaml**, obtain its Azure identity by running the following command:

      ```
      $ az identity list --resource-group "<existing_resource_group>"
      ```

   b. If you did not specify a existing resource group in **install-config.yaml**, locate the resource group that the installer created, and then obtain its Azure identity by running the following commands:

      ```
      $ az group list
      ```

      ```
      $ az identity list --resource-group "<installer_created_resource_group>"
      ```

2. Grant a role assignment to the cluster resource group so that it can write to the Disk Encryption Set by running the following command:

   ```
   $ az role assignment create --role "<privileged_role>" \ 1
     --assignee "<resource_group_identity>" 2
   ```

   1 Specifies an Azure role that has read/write permissions to the disk encryption set. You can use the **Owner** role or a custom role with the necessary permissions.

   2 Specifies the identity of the cluster resource group.

3. Obtain the **id** of the disk encryption set you created prior to installation by running the following command:

```
$ az disk-encryption-set show -n <disk_encryption_set_name> \ 1
   --resource-group <resource_group_name> 2
```

1. Specifies the name of the disk encryption set.
2. Specifies the resource group that contains the disk encryption set. The **id** is in the format of **"/subscriptions/.../resourceGroups/... /providers/Microsoft.Compute/diskEncryptionSets/..."**.

4. Obtain the identity of the cluster service principal by running the following command:

```
$ az identity show -g <cluster_resource_group> \ 1
   -n <cluster_service_principal_name> \ 2
   --query principalId --out tsv
```

1. Specifies the name of the cluster resource group created by the installation program.
2. Specifies the name of the cluster service principal created by the installation program. The identity is in the format of **12345678-1234-1234-1234-1234567890**.

5. Create a role assignment that grants the cluster service principal **Contributor** privileges to the disk encryption set by running the following command:

```
$ az role assignment create --assignee <cluster_service_principal_id> \ 1
   --role 'Contributor' \//
   --scope <disk_encryption_set_id> \ 2
```

1. Specifies the ID of the cluster service principal obtained in the previous step.
2. Specifies the ID of the disk encryption set.

6. Create a storage class that uses the user-managed disk encryption set:

   a. Save the following storage class definition to a file, for example **storage-class-definition.yaml**:

```
kind: StorageClass
apiVersion: storage.k8s.io/v1
metadata:
  name: managed-premium
provisioner: kubernetes.io/azure-disk
parameters:
  skuname: Premium_LRS
  kind: Managed
  diskEncryptionSetID: "<disk_encryption_set_ID>" 1
  resourceGroup: "<resource_group_name>" 2
reclaimPolicy: Delete
allowVolumeExpansion: true
volumeBindingMode: WaitForFirstConsumer
```

1. Specifies the ID of the disk encryption set that you created in the prerequisite steps, for example **"/subscriptions/xxxxxx-xxxxx-xxxxx/resourceGroups/test-encryption/providers/Microsoft.Compute/diskEncryptionSets/disk-encryption-set-xxxxxx"**.
2. Specifies the name of the resource group used by the installer. This is the same resource group from the first step.

b. Create the storage class **managed-premium** from the file you created by running the following command:

```
$ oc create -f storage-class-definition.yaml
```

7. Select the **managed-premium** storage class when you create persistent volumes to use encrypted storage.

6.6.9. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.

IMPORTANT

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.11. Download and install the new version of **oc**.

Installing the OpenShift CLI on Linux

You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the architecture in the **Product Variant** drop-down menu.
3. Select the appropriate version in the **Version** drop-down menu.
4. Click **Download Now** next to the **OpenShift v4.11 Linux Client** entry and save the file.
5. Unpack the archive:

```
$ tar xvf <file>
```

6. Place the **oc** binary in a directory that is on your **PATH**.
   To check your **PATH**, execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.
   To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

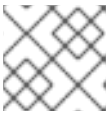
```
C:\> oc <command>
```

Installing the OpenShift CLI on macOS

You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 macOS Client** entry and save the file.



NOTE

For macOS arm64, choose the **OpenShift v4.11 macOS arm64 Client** entry.

4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your PATH.
   To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

6.6.10. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

Example output

```
system:admin
```

Additional resources

- See Accessing the web console for more details about accessing and understanding the OpenShift Container Platform web console.

6.6.11. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.11, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to OpenShift Cluster Manager Hybrid Cloud Console.

After you confirm that your OpenShift Cluster Manager Hybrid Cloud Console inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, use subscription watch to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

Additional resources

- See About remote health monitoring for more information about the Telemetry service

6.6.12. Next steps

- Customize your cluster.
- If necessary, you can opt out of remote health reporting .

6.7. INSTALLING A CLUSTER ON AZURE WITH NETWORK CUSTOMIZATIONS

In OpenShift Container Platform version 4.11, you can install a cluster with a customized network configuration on infrastructure that the installation program provisions on Microsoft Azure. By customizing your network configuration, your cluster can coexist with existing IP address allocations in your environment and integrate with existing MTU and VXLAN configurations.

You must set most of the network configuration parameters during installation, and you can modify only **kubeProxy** configuration parameters in a running cluster.

6.7.1. Prerequisites

- You reviewed details about the OpenShift Container Platform installation and update processes.
- You read the documentation on selecting a cluster installation method and preparing it for users.
- You configured an Azure account to host the cluster and determined the tested and validated region to deploy the cluster to.
- If you use a firewall, you configured it to allow the sites that your cluster requires access to.
- If the cloud identity and access management (IAM) APIs are not accessible in your environment, or if you do not want to store an administrator-level credential secret in the **kube-system** namespace, you can manually create and maintain IAM credentials. Manual mode can also be used in environments where the cloud IAM APIs are not reachable.
- If you use customer-managed encryption keys, you prepared your Azure environment for encryption.

6.7.2. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.11, you require access to the internet to install your cluster.

You must have internet access to:

- Access OpenShift Cluster Manager Hybrid Cloud Console to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access Quay.io to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.

IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

6.7.3. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the **~/.ssh/authorized_keys** list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The **./openshift-install gather** command also requires the SSH public key to be in place on the cluster nodes.

IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.

NOTE

You must use a local key, not one that you configured with platform-specific approaches such as AWS key pairs.

Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N '' -f <path>/<file_name>
```
(1)

(1) Specify the path and file name, such as **~/.ssh/id_ed25519**, of the new SSH key. If you have an existing key pair, ensure your public key is in the your **~/.ssh** directory.

NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS validated or Modules In Process cryptographic libraries on the **x86_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the ~/**.ssh/id_ed25519.pub** public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the **./openshift-install gather** command.

NOTE

On some distributions, default SSH private key identities such as ~/**.ssh/id_rsa** and ~/**.ssh/id_dsa** are managed automatically.

a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

Example output

```
Agent pid 31874
```

NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

1 Specify the path and file name for your SSH private key, such as ~/**.ssh/id_ed25519**

Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

6.7.4. Obtaining the installation program

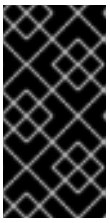
Before you install OpenShift Container Platform, download the installation file on a local computer.

Prerequisites

- You have a computer that runs Linux or macOS, with 500 MB of local disk space.

Procedure

1. Access the Infrastructure Provider page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program that corresponds with your host operating system and architecture, and place the file in the directory where you will store the installation configuration files.



IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.

IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation pull secret from the Red Hat OpenShift Cluster Manager . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

6.7.5. Creating the installation configuration file

You can customize the OpenShift Container Platform cluster you install on Microsoft Azure.

Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.
- Obtain service principal permissions at the subscription level.

Procedure

1. Create the **install-config.yaml** file.

a. Change to the directory that contains the installation program and run the following command:

```
$ ./openshift-install create install-config --dir <installation_directory> 1
```

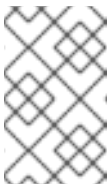
1 For **<installation_directory>**, specify the directory name to store the files that the installation program creates.

When specifying the directory:

- Verify that the directory has the **execute** permission. This permission is required to run Terraform binaries under the installation directory.
- Use an empty directory. Some installation assets, such as bootstrap X.509 certificates, have short expiration intervals, therefore you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

b. At the prompts, provide the configuration details for your cloud:

i. Optional: Select an SSH key to use to access your cluster machines.



NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

ii. Select **azure** as the platform to target.

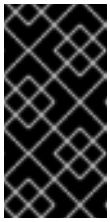
iii. If you do not have a Microsoft Azure profile stored on your computer, specify the following Azure parameter values for your subscription and service principal:

- **azure subscription id** The subscription ID to use for the cluster. Specify the **id** value in your account output.
- **azure tenant id** The tenant ID. Specify the **tenantId** value in your account output.
- **azure service principal client id** The value of the **appId** parameter for the service principal.
- **azure service principal client secret** The value of the **password** parameter for the service principal.

iv. Select the region to deploy the cluster to.

v. Select the base domain to deploy the cluster to. The base domain corresponds to the Azure DNS Zone that you created for your cluster.

vi. Enter a descriptive name for your cluster.



IMPORTANT

All Azure resources that are available through public endpoints are subject to resource name restrictions, and you cannot create resources that use certain terms. For a list of terms that Azure restricts, see Resolve reserved resource name errors in the Azure documentation.

vii. Paste the pull secret from the Red Hat OpenShift Cluster Manager .

2. Modify the **install-config.yaml** file. You can find more information about the available parameters in the "Installation configuration parameters" section.

3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.

IMPORTANT

The **install-config.yaml** file is consumed during the installation process. If you want to reuse the file, you must back it up now.

6.7.5.1. Installation configuration parameters

Before you deploy an OpenShift Container Platform cluster, you provide parameter values to describe your account on the cloud platform that hosts your cluster and optionally customize your cluster's platform. When you create the **install-config.yaml** installation configuration file, you provide values for the required parameters through the command line. If you customize your cluster, you can modify the **install-config.yaml** file to provide more details about the platform.

NOTE

After installation, you cannot modify these parameters in the **install-config.yaml** file.

6.7.5.1.1. Required configuration parameters

Required installation configuration parameters are described in the following table:

Table 6.6. Required parameters

Parameter	Description	Values
apiVersion	The API version for the **install-config.yaml** content. The current version is **v1**. The installer may also support older API versions.	String

Parameter	Description	Values
baseDomain	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the **baseDomain** and **metadata.name** parameter values that uses the **<metadata.name>.<baseDomain>** format.	A fully-qualified domain or subdomain name, such as **example.com**.
metadata	Kubernetes resource **ObjectMeta**, from which only the **name** parameter is consumed.	Object
metadata.name	The name of the cluster. DNS records for the cluster are all subdomains of **{{.metadata.name}}.{{.baseDomain}}**.	String of lowercase letters, hyphens (**-**), and periods (**.**), such as **dev**.
platform	The configuration for the specific platform upon which to perform the installation: **alibabacloud**, **aws**, **baremetal**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**. For additional information about **platform.<platform>** parameters, consult the table for your specific platform that follows.	Object
pullSecret	Get a pull secret from the Red Hat OpenShift Cluster Manager to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	{ "auths":{ "cloud.openshift.com":{ "auth":"b3Blb=", "email":"you@example.com" }, "quay.io":{ "auth":"b3Blb=", "email":"you@example.com" } } }

Parameter	Description	Values

6.7.5.1.2. Network configuration parameters

You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

Only IPv4 addresses are supported.

NOTE

Globalnet is not supported with Red Hat OpenShift Data Foundation disaster recovery solutions. For regional disaster recovery scenarios, ensure that you use a nonoverlapping range of private IP addresses for the cluster and service networks in each cluster.

Table 6.7. Network parameters

Parameter	Description	Values
networking	The configuration for the cluster network.	Object  **NOTE** You cannot modify parameters specified by the **networking** object after installation.

Parameter	Description	Values
networking.networkType	The cluster network provider Container Network Interface (CNI) cluster network provider to install.	Either **OpenShiftSDN** or **OVNKubernetes**. **OpenShiftSDN** is a CNI provider for all-Linux networks. **OVNKubernetes** is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is **OpenShiftSDN**.
networking.clusterNetwork	The IP address blocks for pods. The default value is **10.128.0.0/14** with a host prefix of **/23**. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: networking: clusterNetwork: - cidr: 10.128.0.0/14 hostPrefix: 23
networking.clusterNetwork.cidr	Required if you use **networking.clusterNetwork**. An IP address block. An IPv4 network.	An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between **0** and **32**.
networking.clusterNetwork.hostPrefix	The subnet prefix length to assign to each individual node. For example, if **hostPrefix** is set to **23** then each node is assigned a **/23** subnet out of the given **cidr**. A **hostPrefix** value of **23** provides 510 (2^(32 - 23) - 2) pod IP addresses.	A subnet prefix. The default value is **23**.
networking.serviceNetwork	The IP address block for services. The default value is **172.30.0.0/16**. The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.	An array with an IP address block in CIDR format. For example: networking: serviceNetwork: - 172.30.0.0/16
networking.machineNetwork	The IP address blocks for machines. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: networking: machineNetwork: - cidr: 10.0.0.0/16

Parameter	Description	Values
networking.machineNetwork.cidr	Required if you use **networking.machineNetwork**. An IP address block. The default value is **10.0.0.0/16** for all platforms other than libvirt. For libvirt, the default value is **192.168.126.0/24**.	An IP network block in CIDR notation. For example, **10.0.0.0/16**.  **NOTE** Set the **networking.machineNetwork** to match the CIDR that the preferred NIC resides in.

6.7.5.1.3. Optional configuration parameters

Optional installation configuration parameters are described in the following table:

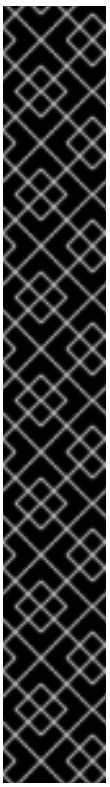
Table 6.8. Optional parameters

Parameter	Description	Values
additionalTrustBundle	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String
capabilities	Controls the installation of optional core cluster components. You can reduce the footprint of your OpenShift Container Platform cluster by disabling optional components.	String array
capabilities.baselineCapabilitySet	Selects an initial set of optional capabilities to enable. Valid values are **None**, **v4.11** and **vCurrent**. **v4.11** enables the **baremetal** Operator, the **marketplace** Operator, and the **openshift-samples** content. **vCurrent** installs the recommended set of capabilities for the current version of OpenShift Container Platform. The default value is **vCurrent**.	String

Parameter	Description	Values
capabilities.additionalEnabledCapabilities	Extends the set of optional capabilities beyond what you specify in **baselineCapabilitySet**. Valid values are **baremetal**, **marketplace** and **openshift-samples**. You may specify multiple capabilities in this parameter.	String array
cgroupsV2	Enables Linux control groups version 2 (cgroups v2) on specific nodes in your cluster. The OpenShift Container Platform process for enabling cgroups v2 disables all cgroup version 1 controllers and hierarchies. The OpenShift Container Platform cgroups version 2 feature is in Developer Preview and is not supported by Red Hat at this time.	**true**
compute	The configuration for the machines that comprise the compute nodes.	Array of **MachinePool** objects.
compute.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** (the default).	String
compute.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  IMPORTANT If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
compute.name	Required if you use **compute**. The name of the machine pool.	**worker**

Parameter	Description	Values
compute.platform	Required if you use **compute**. Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the **controlPlane.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
compute.replicas	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to **2**. The default value is **3**.
controlPlane	The configuration for the machines that comprise the control plane.	Array of **MachinePool** objects.
controlPlane.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** (the default).	String
controlPlane.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  IMPORTANT If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
controlPlane.name	Required if you use **controlPlane**. The name of the machine pool.	**master**

Parameter	Description	Values
controlPlane.platform	Required if you use **controlPlane**. Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the **compute.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
controlPlane.replicas	The number of control plane machines to provision.	The only supported value is **3**, which is the default value.
credentialsMode	The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported.  **NOTE** Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the *Cloud Credential Operator* entry in the *Cluster Operators reference* content.  **NOTE** If your AWS account has service control policies (SCP) enabled, you must configure the **credentialsMode** parameter to **Mint**, **Passthrough** or **Manual**.	**Mint**, **Passthrough**, **Manual** or an empty string (**""**).

Parameter	Description	Values
fips	Enable or disable FIPS mode. The default is **false** (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.  **IMPORTANT** To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.  **NOTE** If you are using Azure File storage, you cannot enable FIPS mode.	**false** or **true**
imageContentSources	Sources and repositories for the release-image content.	Array of objects. Includes a **source** and, optionally, **mirrors**, as described in the following rows of this table.
imageContentSources.source	Required if you use **imageContentSources**. Specify the repository that users refer to, for example, in image pull specifications.	String

Parameter	Description	Values
imageContentSources.mirrors	Specify one or more repositories that may also contain the same images.	Array of strings
publish	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	**Internal** or **External**. To deploy a private cluster, which cannot be accessed from the internet, set **publish** to **Internal**. The default value is **External**.
sshKey	The SSH key to authenticate access to your cluster machines. NOTE For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.	For example, **sshKey: ssh-ed25519 AAAA..**.

6.7.5.1.4. Additional Azure configuration parameters

Additional Azure configuration parameters are described in the following table.

NOTE

By default, if you specify availability zones in the **install-config.yaml** file, the installation program distributes the control plane machines and the compute machines across these availability zones within a region. To ensure high availability for your cluster, select a region with at least three availability zones. If your region contains fewer than three availability zones, the installation program places more than one control plane machine in the available zones.

Table 6.9. Additional Azure parameters

Parameter	Description	Values

Parameter	Description	Values
compute.platform.azure.encryptionAtHost	Enables host-level encryption for compute machines. You can enable this encryption alongside user-managed server-side encryption. This feature encrypts temporary, ephemeral, cached and un-managed disks on the VM host. This is not a prerequisite for user-managed server-side encryption.	**true** or **false**. The default is **false**.
compute.platform.azure.osDisk.diskSizeGB	The Azure disk size for the VM.	Integer that represents the size of the disk in GB. The default is **128**.
compute.platform.azure.osDisk.diskType	Defines the type of disk.	**standard_LRS**, **premium_LRS**, or **standardSSD_LRS**. The default is **premium_LRS**.
compute.platform.azure.ultraSSDCapability	Enables the use of Azure ultra disks for persistent storage on compute nodes. This requires that your Azure region and zone have ultra disks available.	**Enabled**, **Disabled**. The default is **Disabled**.
compute.platform.azure.osDisk.diskEncryptionSet.resourceGroup	The name of the Azure resource group that contains the disk encryption set from the installation prerequisites. This resource group should be different than the resource group where you install the cluster to avoid deleting your Azure encryption key when the cluster is destroyed. This value is only necessary if you intend to install the cluster with user-managed disk encryption.	String, for example **production_encryption_resource_group**.
compute.platform.azure.osDisk.diskEncryptionSet.name	The name of the disk encryption set that contains the encryption key from the installation prerequisites.	String, for example **production_disk_encryption_set**.
compute.platform.azure.osDisk.diskEncryptionSet.subscriptionId	Defines the Azure subscription of the disk encryption set where the disk encryption set resides. This secondary disk encryption set is used to encrypt compute machines.	String, in the format **00000000-0000-0000-0000-000000000000**.

Parameter	Description	Values
compute.platform.azure.vmNetworkingType	Enables accelerated networking. Accelerated networking enables single root I/O virtualization (SR-IOV) to a VM, improving its networking performance. If instance type of compute machines support **Accelerated** networking, by default, the installer enables **Accelerated** networking, otherwise the default networking type is **Basic**.	**Accelerated** or **Basic**.
compute.platform.azure.type	Defines the Azure instance type for compute machines.	String
compute.platform.azure.zones	The availability zones where the installation program creates compute machines.	String list
controlPlane.platform.azure.type	Defines the Azure instance type for control plane machines.	String
controlPlane.platform.azure.zones	The availability zones where the installation program creates control plane machines.	String list
platform.azure.defaultMachinePlatform.encryptionAtHost	Enables host-level encryption for compute machines. You can enable this encryption alongside user-managed server-side encryption. This feature encrypts temporary, ephemeral, cached, and un-managed disks on the VM host. This parameter is not a prerequisite for user-managed server-side encryption.	**true** or **false**. The default is **false**.
platform.azure.defaultMachinePlatform.osDisk.diskEncryptionSet.name	The name of the disk encryption set that contains the encryption key from the installation prerequisites.	String, for example, **production_disk_encryption_set**.
platform.azure.defaultMachinePlatform.osDisk.diskEncryptionSet.resourceGroup	The name of the Azure resource group that contains the disk encryption set from the installation prerequisites. To avoid deleting your Azure encryption key when the cluster is destroyed, this resource group must be different from the resource group where you install the cluster. This value is necessary only if you intend to install the cluster with user-managed disk encryption.	String, for example, **production_encryption_resource_group**.

Parameter	Description	Values
platform.azure.defaultMachinePlatform.osDisk.diskEncryptionSet.subscriptionId	Defines the Azure subscription of the disk encryption set where the disk encryption set resides. This secondary disk encryption set is used to encrypt compute machines.	String, in the format **00000000-0000-0000-0000-000000000000**.
platform.azure.defaultMachinePlatform.osDisk.diskSizeGB	The Azure disk size for the VM.	Integer that represents the size of the disk in GB. The default is **128**.
platform.azure.defaultMachinePlatform.osDisk.diskType	Defines the type of disk.	**premium_LRS** or **standardSSD_LRS**. The default is **premium_LRS**.
platform.azure.defaultMachinePlatform.type	The Azure instance type for control plane and compute machines.	The Azure instance type.
platform.azure.defaultMachinePlatform.zones	The availability zones where the installation program creates compute and control plane machines.	String list.
controlPlane.platform.azure.encryptionAtHost	Enables host-level encryption for control plane machines. You can enable this encryption alongside user-managed server-side encryption. This feature encrypts temporary, ephemeral, cached and un-managed disks on the VM host. This is not a prerequisite for user-managed server-side encryption.	**true** or **false**. The default is **false**.
controlPlane.platform.azure.osDisk.diskEncryptionSet.resourceGroup	The name of the Azure resource group that contains the disk encryption set from the installation prerequisites. This resource group should be different than the resource group where you install the cluster to avoid deleting your Azure encryption key when the cluster is destroyed. This value is only necessary if you intend to install the cluster with user-managed disk encryption.	String, for example **production_encryption_resource_group**.
controlPlane.platform.azure.osDisk.diskEncryptionSet.name	The name of the disk encryption set that contains the encryption key from the installation prerequisites.	String, for example **production_disk_encryption_set**.

Parameter	Description	Values
controlPlane.platform.azure.osDisk.diskEncryptionSet.subscriptionId	Defines the Azure subscription of the disk encryption set where the disk encryption set resides. This secondary disk encryption set is used to encrypt control plane machines.	String, in the format **00000000-0000-0000-0000-000000000000**.
controlPlane.platform.azure.osDisk.diskSizeGB	The Azure disk size for the VM.	Integer that represents the size of the disk in GB. The default is **1024**.
controlPlane.platform.azure.osDisk.diskType	Defines the type of disk.	**premium_LRS** or **standardSSD_LRS**. The default is **premium_LRS**.
controlPlane.platform.azure.ultraSSDCapability	Enables the use of Azure ultra disks for persistent storage on control plane machines. This requires that your Azure region and zone have ultra disks available.	**Enabled**, **Disabled**. The default is **Disabled**.
controlPlane.platform.azure.vmNetworkingType	Enables accelerated networking. Accelerated networking enables single root I/O virtualization (SR-IOV) to a VM, improving its networking performance. If instance type of control plane machines support **Accelerated** networking, by default, the installer enables **Accelerated** networking, otherwise the default networking type is **Basic**.	**Accelerated** or **Basic**.
platform.azure.baseDomainResourceGroupName	The name of the resource group that contains the DNS zone for your base domain.	String, for example **production_cluster**.

Parameter	Description	Values
platform.azure.resourceGroupName	The name of an already existing resource group to install your cluster to. This resource group must be empty and only used for this specific cluster; the cluster components assume ownership of all resources in the resource group. If you limit the service principal scope of the installation program to this resource group, you must ensure all other resources used by the installation program in your environment have the necessary permissions, such as the public DNS zone and virtual network. Destroying the cluster by using the installation program deletes this resource group.	String, for example **existing_resource_group**.
platform.azure.outboundType	The outbound routing strategy used to connect your cluster to the internet. If you are using user-defined routing, you must have pre-existing networking available where the outbound routing has already been configured prior to installing a cluster. The installation program is not responsible for configuring user-defined routing.	**LoadBalancer** or **UserDefinedRouting**. The default is **LoadBalancer**.
platform.azure.region	The name of the Azure region that hosts your cluster.	Any valid region name, such as **centralus**.
platform.azure.zone	List of availability zones to place machines in. For high availability, specify at least two zones.	List of zones, for example **["1", "2", "3"]**.
platform.azure.defaultMachinePlatform.ultraSSDCapability	Enables the use of Azure ultra disks for persistent storage on control plane and compute machines. This requires that your Azure region and zone have ultra disks available.	**Enabled**, **Disabled**. The default is **Disabled**.
platform.azure.networkResourceGroupName	The name of the resource group that contains the existing VNet that you want to deploy your cluster to. This name cannot be the same as the **platform.azure.baseDomainResourceGroupName**.	String.
platform.azure.virtualNetwork	The name of the existing VNet that you want to deploy your cluster to.	String.

Parameter	Description	Values
platform.azure.controlPlaneSubnet	The name of the existing subnet in your VNet that you want to deploy your control plane machines to.	Valid CIDR, for example **10.0.0.0/16**.
platform.azure.computeSubnet	The name of the existing subnet in your VNet that you want to deploy your compute machines to.	Valid CIDR, for example **10.0.0.0/16**.
platform.azure.cloudName	The name of the Azure cloud environment that is used to configure the Azure SDK with the appropriate Azure API endpoints. If empty, the default value **AzurePublicCloud** is used.	Any valid cloud environment, such as **AzurePublicCloud** or **AzureUSGovernmentCloud**.
platform.azure.defaultMachinePlatform.vmNetworkingType	Enables accelerated networking. Accelerated networking enables single root I/O virtualization (SR-IOV) to a VM, improving its networking performance.	**Accelerated** or **Basic**. If instance type of control plane and compute machines support **Accelerated** networking, by default, the installer enables **Accelerated** networking, otherwise the default networking type is **Basic**.

NOTE

You cannot customize Azure Availability Zones or Use tags to organize your Azure resources with an Azure cluster.

6.7.5.2. Minimum resource requirements for cluster installation

Each cluster machine must meet the following minimum requirements:

Table 6.10. Minimum resource requirements

Machine	Operating System	vCPU [1]	Virtual RAM	Storage	IOPS [2]
Bootstrap	RHCOS	4	16 GB	100 GB	300
Control plane	RHCOS	4	16 GB	100 GB	300
Compute	RHCOS, RHEL 8.6 and later [3]	2	8 GB	100 GB	300

1. One vCPU is equivalent to one physical core when simultaneous multithreading (SMT), or hyperthreading, is not enabled. When enabled, use the following formula to calculate the corresponding ratio: (threads per core × cores) × sockets = vCPUs.

2. OpenShift Container Platform and Kubernetes are sensitive to disk performance, and faster storage is recommended, particularly for etcd on the control plane nodes which require a 10 ms p99 fsync duration. Note that on many cloud platforms, storage size and IOPS scale together, so you might need to over-allocate storage volume to obtain sufficient performance.

3. As with all user-provisioned installations, if you choose to use RHEL compute machines in your cluster, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks. Use of RHEL 7 compute machines is deprecated and has been removed in OpenShift Container Platform 4.10 and later.

IMPORTANT

You are required to use Azure virtual machines that have the **premiumIO** parameter set to **true**.

If an instance type for your platform meets the minimum requirements for cluster machines, it is supported to use in OpenShift Container Platform.

Additional resources

- Optimizing storage

6.7.5.3. Tested instance types for Azure

The following Microsoft Azure instance types have been tested with OpenShift Container Platform.

Example 6.2. Machine types

- **c4.***
- **c5.***
- **c5a.***
- **i3.***
- **m4.***
- **m5.***
- **m5a.***
- **m6a.***
- **m6i.***
- **r4.***
- **r5.***
- **r5a.***
- **r6i.***
- **t3.***

- **t3a.***

6.7.5.4. Sample customized install-config.yaml file for Azure

You can customize the **install-config.yaml** file to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.

IMPORTANT

This sample YAML file is provided for reference only. You must obtain your **install-config.yaml** file by using the installation program and modify it.

```
apiVersion: v1
baseDomain: example.com (1)
controlPlane: (2)
  hyperthreading: Enabled (3) (4)
  name: master
  platform:
    azure:
      encryptionAtHost: true
      ultraSSDCapability: Enabled
      osDisk:
        diskSizeGB: 1024 (5)
        diskType: Premium_LRS
        diskEncryptionSet:
          resourceGroup: disk_encryption_set_resource_group
          name: disk_encryption_set_name
          subscriptionId: secondary_subscription_id
      type: Standard_D8s_v3
  replicas: 3
compute: (6)
- hyperthreading: Enabled (7)
  name: worker
  platform:
    azure:
      ultraSSDCapability: Enabled
      type: Standard_D2s_v3
      encryptionAtHost: true
      osDisk:
        diskSizeGB: 512 (8)
        diskType: Standard_LRS
        diskEncryptionSet:
          resourceGroup: disk_encryption_set_resource_group
          name: disk_encryption_set_name
          subscriptionId: secondary_subscription_id
      zones: (9)
      - "1"
      - "2"
      - "3"
  replicas: 5
metadata:
  name: test-cluster (10)
```

```
networking: (11)
  clusterNetwork:
  - cidr: 10.128.0.0/14
    hostPrefix: 23
  machineNetwork:
  - cidr: 10.0.0.0/16
  networkType: OpenShiftSDN
  serviceNetwork:
  - 172.30.0.0/16
platform:
  azure:
    defaultMachinePlatform:
      ultraSSDCapability: Enabled
    baseDomainResourceGroupName: resource_group (12)
    region: centralus (13)
    resourceGroupName: existing_resource_group (14)
    outboundType: Loadbalancer
    cloudName: AzurePublicCloud
pullSecret: '{"auths": ...}' (15)
fips: false (16)
sshKey: ssh-ed25519 AAAA... (17)
```

(1) (10) (13) (15) Required. The installation program prompts you for this value.

(2) (6) (11) If you do not provide these parameters and values, the installation program provides the default value.

(3) (7) The **controlPlane** section is a single mapping, but the **compute** section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, **-**, and the first line of the **controlPlane** section must not. Only one control plane pool is used.

(4) Whether to enable or disable simultaneous multithreading, or **hyperthreading**. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores. You can disable it by setting the parameter value to **Disabled**. If you disable simultaneous multithreading in some cluster machines, you must disable it in all cluster machines.

IMPORTANT

If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance. Use larger virtual machine types, such as **Standard_D8s_v3**, for your machines if you disable simultaneous multithreading.

(5) (8) You can specify the size of the disk to use in GB. Minimum recommendation for control plane nodes is 1024 GB.

(9) Specify a list of zones to deploy your machines to. For high availability, specify at least two zones.

(12) Specify the name of the resource group that contains the DNS zone for your base domain.

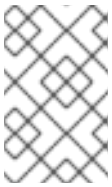
(14) Specify the name of an already existing resource group to install your cluster to. If undefined, a new resource group is created for the cluster.

(16) Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is

IMPORTANT

To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.

17 You can optionally provide the **sshKey** value that you use to access the machines in your cluster.



NOTE

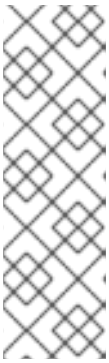
For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

6.7.5.5. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.



NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
```

```
additionalTrustBundle: | 4
  -----BEGIN CERTIFICATE-----
  <MY_TRUSTED_CA_CERT>
  -----END CERTIFICATE-----
```

1. A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
2. A proxy URL to use for creating HTTPS connections outside the cluster.
3. A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use * to bypass the proxy for all destinations.
4. If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace that contains one or more additional CA certificates that are required for proxying HTTPS connections. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges these contents with the Red Hat Enterprise Linux CoreOS (RHCOS) trust bundle, and this config map is referenced in the **trustedCA** field of the **Proxy** object. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.

NOTE

The installation program does not support the proxy **readinessEndpoints** field.

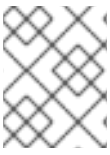
NOTE

If the installer times out, restart and then complete the deployment by using the **wait-for** command of the installer. For example:

```
$ ./openshift-install wait-for install-complete --log-level debug
```

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.



NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

6.7.6. Network configuration phases

There are two phases prior to OpenShift Container Platform installation where you can customize the network configuration.

Phase 1

You can customize the following network-related fields in the **install-config.yaml** file before you create the manifest files:

- **networking.networkType**
- **networking.clusterNetwork**
- **networking.serviceNetwork**
- **networking.machineNetwork**
  For more information on these fields, refer to *Installation configuration parameters*.

NOTE

Set the **networking.machineNetwork** to match the CIDR that the preferred NIC resides in.

IMPORTANT

The CIDR range **172.17.0.0/16** is reserved by libVirt. You cannot use this range or any range that overlaps with this range for any networks in your cluster.

Phase 2

After creating the manifest files by running **openshift-install create manifests**, you can define a customized Cluster Network Operator manifest with only the fields you want to modify. You can use the manifest to specify advanced network configuration.

You cannot override the values specified in phase 1 in the **install-config.yaml** file during phase 2. However, you can further customize the cluster network provider during phase 2.

6.7.7. Specifying advanced network configuration

You can use advanced network configuration for your cluster network provider to integrate your cluster into your existing network environment. You can specify advanced network configuration only before you install the cluster.

IMPORTANT

Customizing your network configuration by modifying the OpenShift Container Platform manifest files created by the installation program is not supported. Applying a manifest file that you create, as in the following procedure, is supported.

Prerequisites

- You have created the **install-config.yaml** file and completed any modifications to it.

Procedure

1. Change to the directory that contains the installation program and create the manifests:

```
$ ./openshift-install create manifests --dir <installation_directory> 1
```

1 **<installation_directory>** specifies the name of the directory that contains the **install-config.yaml** file for your cluster.

2. Create a stub manifest file for the advanced network configuration that is named **cluster-network-03-config.yml** in the **<installation_directory>/manifests/** directory:

```
apiVersion: operator.openshift.io/v1
kind: Network
metadata:
  name: cluster
spec:
```

3. Specify the advanced network configuration for your cluster in the **cluster-network-03-config.yml** file, such as in the following examples:

   Specify a different VXLAN port for the OpenShift SDN network provider

```
apiVersion: operator.openshift.io/v1
kind: Network
metadata:
  name: cluster
spec:
  defaultNetwork:
    openshiftSDNConfig:
      vxlanPort: 4800
```

   Enable IPsec for the OVN-Kubernetes network provider

```
apiVersion: operator.openshift.io/v1
kind: Network
metadata:
  name: cluster
spec:
  defaultNetwork:
    ovnKubernetesConfig:
      ipsecConfig: {}
```

4. Optional: Back up the **manifests/cluster-network-03-config.yml** file. The installation program consumes the **manifests/** directory when you create the Ignition config files.

6.7.8. Cluster Network Operator configuration

The configuration for the cluster network is specified as part of the Cluster Network Operator (CNO) configuration and stored in a custom resource (CR) object that is named **cluster**. The CR specifies the fields for the **Network** API in the **operator.openshift.io** API group.

The CNO configuration inherits the following fields during cluster installation from the **Network** API in the **Network.config.openshift.io** API group and these fields cannot be changed:

clusterNetwork

IP address pools from which pod IP addresses are allocated.

serviceNetwork

IP address pool for services.

defaultNetwork.type

Cluster network provider, such as OpenShift SDN or OVN-Kubernetes.

You can specify the cluster network provider configuration for your cluster by setting the fields for the **defaultNetwork** object in the CNO object named **cluster**.

6.7.8.1. Cluster Network Operator configuration object

The fields for the Cluster Network Operator (CNO) are described in the following table:

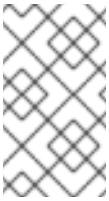
Table 6.11. Cluster Network Operator configuration object

Field	Type	Description
metadata.name	**string**	The name of the CNO object. This name is always **cluster**.
spec.clusterNetwork	**array**	A list specifying the blocks of IP addresses from which pod IP addresses are allocated and the subnet prefix length assigned to each individual node in the cluster. For example: `spec:` `  clusterNetwork:` `  - cidr: 10.128.0.0/19` `  hostPrefix: 23` `  - cidr: 10.128.32.0/19` `  hostPrefix: 23` You can customize this field only in the **install-config.yaml** file before you create the manifests. The value is read-only in the manifest file.
spec.serviceNetwork	**array**	A block of IP addresses for services. The OpenShift SDN and OVN-Kubernetes Container Network Interface (CNI) network providers support only a single IP address block for the service network. For example: `spec:` `  serviceNetwork:` `  - 172.30.0.0/14` You can customize this field only in the **install-config.yaml** file before you create the manifests. The value is read-only in the manifest file.
spec.defaultNetwork	**object**	Configures the Container Network Interface (CNI) cluster network provider for the cluster network.

Field	Type	Description
spec.kubeProxyConfig	**object**	The fields for this object specify the kube-proxy configuration. If you are using the OVN-Kubernetes cluster network provider, the kube-proxy configuration has no effect.

defaultNetwork object configuration
The values for the **defaultNetwork** object are defined in the following table:

Table 6.12. **defaultNetwork** object

Field	Type	Description
type	**string**	Either **OpenShiftSDN** or **OVNKubernetes**. The cluster network provider is selected during installation. This value cannot be changed after cluster installation.  NOTE OpenShift Container Platform uses the OpenShift SDN Container Network Interface (CNI) cluster network provider by default.
openshiftSDNConfig	**object**	This object is only valid for the OpenShift SDN cluster network provider.
ovnKubernetesConfig	**object**	This object is only valid for the OVN-Kubernetes cluster network provider.

Configuration for the OpenShift SDN CNI cluster network provider
The following table describes the configuration fields for the OpenShift SDN Container Network Interface (CNI) cluster network provider.

Table 6.13. **openshiftSDNConfig** object

Field	Type	Description
mode	**string**	Configures the network isolation mode for OpenShift SDN. The default value is **NetworkPolicy**. The values **Multitenant** and **Subnet** are available for backwards compatibility with OpenShift Container Platform 3.x but are not recommended. This value cannot be changed after cluster installation.

Field	Type	Description
mtu	**integer**	The maximum transmission unit (MTU) for the VXLAN overlay network. This is detected automatically based on the MTU of the primary network interface. You do not normally need to override the detected MTU. If the auto-detected value is not what you expect it to be, confirm that the MTU on the primary network interface on your nodes is correct. You cannot use this option to change the MTU value of the primary network interface on the nodes. If your cluster requires different MTU values for different nodes, you must set this value to **50** less than the lowest MTU value in your cluster. For example, if some nodes in your cluster have an MTU of **9001**, and some have an MTU of**1500**, you must set this value to **1450**. This value cannot be changed after cluster installation.
vxlanPort	**integer**	The port to use for all VXLAN packets. The default value is **4789**. This value cannot be changed after cluster installation. If you are running in a virtualized environment with existing nodes that are part of another VXLAN network, then you might be required to change this. For example, when running an OpenShift SDN overlay on top of VMware NSX-T, you must select an alternate port for the VXLAN, because both SDNs use the same default VXLAN port number. On Amazon Web Services (AWS), you can select an alternate port for the VXLAN between port **9000** and port **9999**.

Example OpenShift SDN configuration

```
defaultNetwork:
  type: OpenShiftSDN
  openshiftSDNConfig:
    mode: NetworkPolicy
    mtu: 1450
    vxlanPort: 4789
```

Configuration for the OVN-Kubernetes CNI cluster network provider

The following table describes the configuration fields for the OVN-Kubernetes CNI cluster network provider.

Table 6.14. ovnKubernetesConfig object

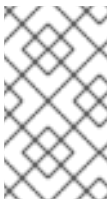
Field	Type	Description
mtu	**integer**	The maximum transmission unit (MTU) for the Geneve (Generic Network Virtualization Encapsulation) overlay network. This is detected automatically based on the MTU of the primary network interface. You do not normally need to override the detected MTU. If the auto-detected value is not what you expect it to be, confirm that the MTU on the primary network interface on your nodes is correct. You cannot use this option to change the MTU value of the primary network interface on the nodes. If your cluster requires different MTU values for different nodes, you must set this value to **100** less than the lowest MTU value in your cluster. For example, if some nodes in your cluster have an MTU of **9001**, and some have an MTU of**1500**, you must set this value to **1400**.
genevePort	**integer**	The port to use for all Geneve packets. The default value is **6081**. This value cannot be changed after cluster installation.
ipsecConfig	**object**	Specify an empty object to enable IPsec encryption.
policyAuditConfig	**object**	Specify a configuration object for customizing network policy audit logging. If unset, the defaults audit log settings are used.
gatewayConfig	**object**	Optional: Specify a configuration object for customizing how egress traffic is sent to the node gateway.  **NOTE** While migrating egress traffic, you can expect some disruption to workloads and service traffic until the Cluster Network Operator (CNO) successfully rolls out the changes.

Table 6.15. **policyAuditConfig** object

Field	Type	Description
rateLimit	integer	The maximum number of messages to generate every second per node. The default value is **20** messages per second.
maxFileSize	integer	The maximum size for the audit log in bytes. The default value is **50000000** or 50 MB.

Field	Type	Description
destination	string	One of the following additional audit log targets: **libc** The libc **syslog()** function of the journald process on the host. **udp:<host>:<port>** A syslog server. Replace **<host>:<port>** with the host and port of the syslog server. **unix:<file>** A Unix Domain Socket file specified by **<file>**. **null** Do not send the audit logs to any additional target.
syslogFacility	string	The syslog facility, such as **kern**, as defined by RFC5424. The default value is **local0**.

Table 6.16. **gatewayConfig** object

Field	Type	Description
routingViaHost	**boolean**	Set this field to **true** to send egress traffic from pods to the host networking stack. For highly-specialized installations and applications that rely on manually configured routes in the kernel routing table, you might want to route egress traffic to the host networking stack. By default, egress traffic is processed in OVN to exit the cluster and is not affected by specialized routes in the kernel routing table. The default value is **false**. This field has an interaction with the Open vSwitch hardware offloading feature. If you set this field to **true**, you do not receive the performance benefits of the offloading because egress traffic is processed by the host networking stack.

Example OVN-Kubernetes configuration with IPSec enabled

```
defaultNetwork:
  type: OVNKubernetes
  ovnKubernetesConfig:
    mtu: 1400
    genevePort: 6081
    ipsecConfig: {}
```

kubeProxyConfig object configuration

The values for the **kubeProxyConfig** object are defined in the following table:

Table 6.17. **kubeProxyConfig** object

Field	Type	Description
iptablesSyncPeriod	**string**	The refresh period for **iptables** rules. The default value is **30s**. Valid suffixes include **s**, **m**, and **h** and are described in the Go **time** package documentation. NOTE Because of performance improvements introduced in OpenShift Container Platform 4.3 and greater, adjusting the **iptablesSyncPeriod** parameter is no longer necessary.
proxyArguments.iptables-min-sync-period	**array**	The minimum duration before refreshing **iptables** rules. This field ensures that the refresh does not happen too frequently. Valid suffixes include **s**, **m**, and **h** and are described in the Go **time** package. The default value is: kubeProxyConfig: proxyArguments: iptables-min-sync-period: - 0s

6.7.9. Configuring hybrid networking with OVN-Kubernetes

You can configure your cluster to use hybrid networking with OVN-Kubernetes. This allows a hybrid cluster that supports different node networking configurations. For example, this is necessary to run both Linux and Windows nodes in a cluster.

IMPORTANT

You must configure hybrid networking with OVN-Kubernetes during the installation of your cluster. You cannot switch to hybrid networking after the installation process.

Prerequisites

- You defined **OVNKubernetes** for the **networking.networkType** parameter in the **install-config.yaml** file. See the installation documentation for configuring OpenShift Container Platform network customizations on your chosen cloud provider for more information.

Procedure

1. Change to the directory that contains the installation program and create the manifests:

```
$ ./openshift-install create manifests --dir <installation_directory>
```

where:

<installation_directory>

Specifies the name of the directory that contains the **install-config.yaml** file for your cluster.

2. Create a stub manifest file for the advanced network configuration that is named **cluster-network-03-config.yml** in the **<installation_directory>/manifests/** directory:

```
$ cat <<EOF > <installation_directory>/manifests/cluster-network-03-config.yml
apiVersion: operator.openshift.io/v1
kind: Network
metadata:
  name: cluster
spec:
EOF
```

where:

<installation_directory>

Specifies the directory name that contains the **manifests/** directory for your cluster.

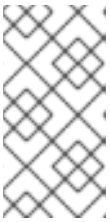
3. Open the **cluster-network-03-config.yml** file in an editor and configure OVN-Kubernetes with hybrid networking, such as in the following example:

Specify a hybrid networking configuration

```
apiVersion: operator.openshift.io/v1
kind: Network
metadata:
  name: cluster
spec:
  defaultNetwork:
    ovnKubernetesConfig:
      hybridOverlayConfig:
        hybridClusterNetwork: 1
        - cidr: 10.132.0.0/14
          hostPrefix: 23
        hybridOverlayVXLANPort: 9898 2
```

1 Specify the CIDR configuration used for nodes on the additional overlay network. The **hybridClusterNetwork** CIDR cannot overlap with the **clusterNetwork** CIDR.

2 Specify a custom VXLAN port for the additional overlay network. This is required for running Windows nodes in a cluster installed on vSphere, and must not be configured for any other cloud provider. The custom port can be any open port excluding the default **4789** port. For more information on this requirement, see the Microsoft documentation on Pod-to-pod connectivity between hosts is broken.



NOTE

Windows Server Long-Term Servicing Channel (LTSC): Windows Server 2019 is not supported on clusters with a custom **hybridOverlayVXLANPort** value because this Windows server version does not support selecting a custom VXLAN port.

4. Save the **cluster-network-03-config.yml** file and quit the text editor.

5. Optional: Back up the **manifests/cluster-network-03-config.yml** file. The installation program deletes the **manifests/** directory when creating the cluster.

NOTE

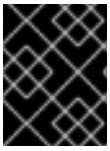
For more information on using Linux and Windows nodes in the same cluster, see Understanding Windows container workloads.

Additional resources

- For more details about Accelerated Networking, see Accelerated Networking for Microsoft Azure VMs.

6.7.10. Deploying the cluster

You can install OpenShift Container Platform on a compatible cloud platform.



IMPORTANT

You can run the **create cluster** command of the installation program only once, during initial installation.

Prerequisites

- Configure an account with the cloud platform that hosts your cluster.
- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.

Procedure

- Change to the directory that contains the installation program and initialize the cluster deployment:

```
$ ./openshift-install create cluster --dir <installation_directory> \ 1
    --log-level=info 2
```

1 For **<installation_directory>**, specify the location of your customized **./install-config.yaml** file.

2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

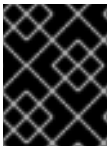
NOTE

If the cloud provider account that you configured on your host does not have sufficient permissions to deploy the cluster, the installation process stops, and the missing permissions are displayed.

Verification

When the cluster deployment completes successfully:

- The terminal displays directions for accessing your cluster, including a link to the web console and credentials for the **kubeadmin** user.
- Credential information also outputs to **<installation_directory>/.openshift_install.log**.

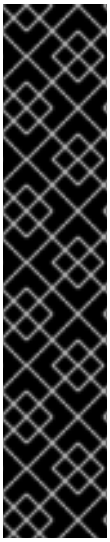


IMPORTANT

Do not delete the installation program or the files that the installation program creates. Both are required to delete the cluster.

Example output

```
...
INFO Install complete!
INFO To access the cluster as the system:admin user when using 'oc', run 'export
KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
INFO Access the OpenShift web-console here: https://console-openshift-
console.apps.mycluster.example.com
INFO Login to the console with user: "kubeadmin", and password: "password"
INFO Time elapsed: 36m22s
```



IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

6.7.11. Finalizing user-managed encryption after installation

If you installed OpenShift Container Platform using a user-managed encryption key, you can complete the installation by creating a new storage class and granting write permissions to the Azure cluster resource group.

Procedure

1. Obtain the identity of the cluster resource group used by the installer:
   a. If you specified an existing resource group in **install-config.yaml**, obtain its Azure identity by running the following command:

```
$ az identity list --resource-group "<existing_resource_group>"
```

b. If you did not specify a existing resource group in **install-config.yaml**, locate the resource group that the installer created, and then obtain its Azure identity by running the following commands:

```
$ az group list
```

```
$ az identity list --resource-group "<installer_created_resource_group>"
```

2. Grant a role assignment to the cluster resource group so that it can write to the Disk Encryption Set by running the following command:

```
$ az role assignment create --role "<privileged_role>" \ (1)
  --assignee "<resource_group_identity>" (2)
```

(1) Specifies an Azure role that has read/write permissions to the disk encryption set. You can use the **Owner** role or a custom role with the necessary permissions.

(2) Specifies the identity of the cluster resource group.

3. Obtain the **id** of the disk encryption set you created prior to installation by running the following command:

```
$ az disk-encryption-set show -n <disk_encryption_set_name> \ (1)
  --resource-group <resource_group_name> (2)
```

(1) Specifies the name of the disk encryption set.

(2) Specifies the resource group that contains the disk encryption set. The **id** is in the format of **"/subscriptions/.../resourceGroups/... /providers/Microsoft.Compute/diskEncryptionSets/..."**.

4. Obtain the identity of the cluster service principal by running the following command:

```
$ az identity show -g <cluster_resource_group> \ (1)
  -n <cluster_service_principal_name> \ (2)
  --query principalId --out tsv
```

(1) Specifies the name of the cluster resource group created by the installation program.

(2) Specifies the name of the cluster service principal created by the installation program. The identity is in the format of **12345678-1234-1234-1234-1234567890**.

5. Create a role assignment that grants the cluster service principal **Contributor** privileges to the disk encryption set by running the following command:

```
$ az role assignment create --assignee <cluster_service_principal_id> \ (1)
  --role 'Contributor' \//
  --scope <disk_encryption_set_id> \ (2)
```

(1) Specifies the ID of the cluster service principal obtained in the previous step.

2 Specifies the ID of the disk encryption set.

6. Create a storage class that uses the user-managed disk encryption set:

   a. Save the following storage class definition to a file, for example **storage-class-definition.yaml**:

```
kind: StorageClass
apiVersion: storage.k8s.io/v1
metadata:
  name: managed-premium
provisioner: kubernetes.io/azure-disk
parameters:
  skuname: Premium_LRS
  kind: Managed
  diskEncryptionSetID: "<disk_encryption_set_ID>" 1
  resourceGroup: "<resource_group_name>" 2
reclaimPolicy: Delete
allowVolumeExpansion: true
volumeBindingMode: WaitForFirstConsumer
```

   1 Specifies the ID of the disk encryption set that you created in the prerequisite steps, for example **"/subscriptions/xxxxxx-xxxxx-xxxxx/resourceGroups/test-encryption/providers/Microsoft.Compute/diskEncryptionSets/disk-encryption-set-xxxxxx"**.

   2 Specifies the name of the resource group used by the installer. This is the same resource group from the first step.

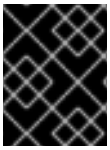
   b. Create the storage class **managed-premium** from the file you created by running the following command:

```
$ oc create -f storage-class-definition.yaml
```

7. Select the **managed-premium** storage class when you create persistent volumes to use encrypted storage.

6.7.12. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.



IMPORTANT

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.11. Download and install the new version of **oc**.

Installing the OpenShift CLI on Linux
You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the architecture in the **Product Variant** drop-down menu.
3. Select the appropriate version in the **Version** drop-down menu.
4. Click **Download Now** next to the **OpenShift v4.11 Linux Client** entry and save the file.
5. Unpack the archive:

```
$ tar xvf <file>
```

6. Place the **oc** binary in a directory that is on your **PATH**.
   To check your **PATH**, execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.
   To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
C:\> oc <command>
```

Installing the OpenShift CLI on macOS

You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 macOS Client** entry and save the file.

NOTE

For macOS arm64, choose the **OpenShift v4.11 macOS arm64 Client** entry.

4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your PATH.
To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

6.7.13. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

Example output

```
-
```

```
system:admin
```

Additional resources

- See Accessing the web console for more details about accessing and understanding the OpenShift Container Platform web console.

6.7.14. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.11, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to OpenShift Cluster Manager Hybrid Cloud Console.

After you confirm that your OpenShift Cluster Manager Hybrid Cloud Console inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, use subscription watch to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

Additional resources

- See About remote health monitoring for more information about the Telemetry service

6.7.15. Next steps

- Customize your cluster.
- If necessary, you can opt out of remote health reporting .

6.8. INSTALLING A CLUSTER ON AZURE INTO AN EXISTING VNET

In OpenShift Container Platform version 4.11, you can install a cluster into an existing Azure Virtual Network (VNet) on Microsoft Azure. The installation program provisions the rest of the required infrastructure, which you can further customize. To customize the installation, you modify parameters in the **install-config.yaml** file before you install the cluster.

6.8.1. Prerequisites

- You reviewed details about the OpenShift Container Platform installation and update processes.
- You read the documentation on selecting a cluster installation method and preparing it for users.
- You configured an Azure account to host the cluster and determined the tested and validated region to deploy the cluster to.
- If you use a firewall, you configured it to allow the sites that your cluster requires access to.
- If the cloud identity and access management (IAM) APIs are not accessible in your environment, or if you do not want to store an administrator-level credential secret in the **kube-system** namespace, you can manually create and maintain IAM credentials.

- If you use customer-managed encryption keys, you prepared your Azure environment for encryption.

6.8.2. About reusing a VNet for your OpenShift Container Platform cluster

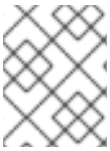
In OpenShift Container Platform 4.11, you can deploy a cluster into an existing Azure Virtual Network (VNet) in Microsoft Azure. If you do, you must also use existing subnets within the VNet and routing rules.

By deploying OpenShift Container Platform into an existing Azure VNet, you might be able to avoid service limit constraints in new accounts or more easily abide by the operational constraints that your company's guidelines set. This is a good option to use if you cannot obtain the infrastructure creation permissions that are required to create the VNet.

6.8.2.1. Requirements for using your VNet

When you deploy a cluster by using an existing VNet, you must perform additional network configuration before you install the cluster. In installer-provisioned infrastructure clusters, the installer usually creates the following components, but it does not create them when you install into an existing VNet:

- Subnets
- Route tables
- VNets
- Network Security Groups



NOTE

The installation program requires that you use the cloud-provided DNS server. Using a custom DNS server is not supported and causes the installation to fail.

If you use a custom VNet, you must correctly configure it and its subnets for the installation program and the cluster to use. The installation program cannot subdivide network ranges for the cluster to use, set route tables for the subnets, or set VNet options like DHCP, so you must do so before you install the cluster.

The cluster must be able to access the resource group that contains the existing VNet and subnets. While all of the resources that the cluster creates are placed in a separate resource group that it creates, some network resources are used from a separate group. Some cluster Operators must be able to access resources in both resource groups. For example, the Machine API controller attaches NICS for the virtual machines that it creates to subnets from the networking resource group.

Your VNet must meet the following characteristics:

- The VNet's CIDR block must contain the **Networking.MachineCIDR** range, which is the IP address pool for cluster machines.
- The VNet and its subnets must belong to the same resource group, and the subnets must be configured to use Azure-assigned DHCP IP addresses instead of static IP addresses.

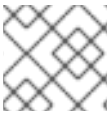
You must provide two subnets within your VNet, one for the control plane machines and one for the compute machines. Because Azure distributes machines in different availability zones within the region that you specify, your cluster will have high availability by default.

NOTE

By default, if you specify availability zones in the **install-config.yaml** file, the installation program distributes the control plane machines and the compute machines across these availability zones within a region. To ensure high availability for your cluster, select a region with at least three availability zones. If your region contains fewer than three availability zones, the installation program places more than one control plane machine in the available zones.

To ensure that the subnets that you provide are suitable, the installation program confirms the following data:

- All the specified subnets exist.
- There are two private subnets, one for the control plane machines and one for the compute machines.
- The subnet CIDRs belong to the machine CIDR that you specified. Machines are not provisioned in availability zones that you do not provide private subnets for. If required, the installation program creates public load balancers that manage the control plane and worker nodes, and Azure allocates a public IP address to them.

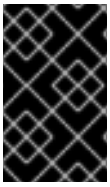


NOTE

If you destroy a cluster that uses an existing VNet, the VNet is not deleted.

6.8.2.1.1. Network security group requirements

The network security groups for the subnets that host the compute and control plane machines require specific access to ensure that the cluster communication is correct. You must create rules to allow access to the required cluster communication ports.

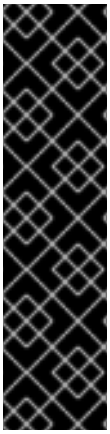


IMPORTANT

The network security group rules must be in place before you install the cluster. If you attempt to install a cluster without the required access, the installation program cannot reach the Azure APIs, and installation fails.

Table 6.18. Required ports

Port	Description	Control plane	Compute
80	Allows HTTP traffic		x
443	Allows HTTPS traffic		x
6443	Allows communication to the control plane machines	x	
22623	Allows internal communication to the machine config server for provisioning machines	x	



IMPORTANT

Currently, there is no supported way to block or restrict the machine config server endpoint. The machine config server must be exposed to the network so that newly-provisioned machines, which have no existing configuration or state, are able to fetch their configuration. In this model, the root of trust is the certificate signing requests (CSR) endpoint, which is where the kubelet sends its certificate signing request for approval to join the cluster. Because of this, machine configs should not be used to distribute sensitive information, such as secrets and certificates.

To ensure that the machine config server endpoints, ports 22623 and 22624, are secured in bare metal scenarios, customers must configure proper network policies.

Because cluster components do not modify the user-provided network security groups, which the Kubernetes controllers update, a pseudo-network security group is created for the Kubernetes controller to modify without impacting the rest of the environment.

Additional resources

- About the OpenShift SDN network plugin

6.8.2.2. Division of permissions

Starting with OpenShift Container Platform 4.3, you do not need all of the permissions that are required for an installation program-provisioned infrastructure cluster to deploy a cluster. This change mimics the division of permissions that you might have at your company: some individuals can create different resources in your clouds than others. For example, you might be able to create application-specific items, like instances, storage, and load balancers, but not networking-related components such as VNets, subnet, or ingress rules.

The Azure credentials that you use when you create your cluster do not need the networking permissions that are required to make VNets and core networking components within the VNet, such as subnets, routing tables, internet gateways, NAT, and VPN. You still need permission to make the application resources that the machines within the cluster require, such as load balancers, security groups, storage accounts, and nodes.

6.8.2.3. Isolation between clusters

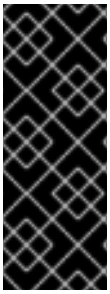
Because the cluster is unable to modify network security groups in an existing subnet, there is no way to isolate clusters from each other on the VNet.

6.8.3. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.11, you require access to the internet to install your cluster.

You must have internet access to:

- Access OpenShift Cluster Manager Hybrid Cloud Console to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access Quay.io to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.



IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

6.8.4. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the **~/.ssh/authorized_keys** list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The **./openshift-install gather** command also requires the SSH public key to be in place on the cluster nodes.

IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.

NOTE

You must use a local key, not one that you configured with platform-specific approaches such as AWS key pairs.

Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N '' -f <path>/<file_name> 1
```

1 Specify the path and file name, such as **~/.ssh/id_ed25519**, of the new SSH key. If you have an existing key pair, ensure your public key is in the your **~/.ssh** directory.

NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS validated or Modules In Process cryptographic libraries on the **x86_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

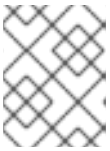
2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the ~/**.ssh/id_ed25519.pub** public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the **./openshift-install gather** command.



NOTE

On some distributions, default SSH private key identities such as ~/**.ssh/id_rsa** and ~/**.ssh/id_dsa** are managed automatically.

a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

Example output

```
Agent pid 31874
```

NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

1 Specify the path and file name for your SSH private key, such as ~/**.ssh/id_ed25519**

Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

6.8.5. Obtaining the installation program

Before you install OpenShift Container Platform, download the installation file on a local computer.

Prerequisites

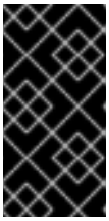
- You have a computer that runs Linux or macOS, with 500 MB of local disk space.

Procedure

1. Access the Infrastructure Provider page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program that corresponds with your host operating system and architecture, and place the file in the directory where you will store the installation configuration files.

IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.



IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation pull secret from the Red Hat OpenShift Cluster Manager . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

6.8.6. Creating the installation configuration file

You can customize the OpenShift Container Platform cluster you install on Microsoft Azure.

Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.
- Obtain service principal permissions at the subscription level.

Procedure

1. Create the **install-config.yaml** file.
   a. Change to the directory that contains the installation program and run the following

command:

```
$ ./openshift-install create install-config --dir <installation_directory> 1
```

1 For **<installation_directory>**, specify the directory name to store the files that the installation program creates.

When specifying the directory:

- Verify that the directory has the **execute** permission. This permission is required to run Terraform binaries under the installation directory.
- Use an empty directory. Some installation assets, such as bootstrap X.509 certificates, have short expiration intervals, therefore you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

b. At the prompts, provide the configuration details for your cloud:

i. Optional: Select an SSH key to use to access your cluster machines.

NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

ii. Select **azure** as the platform to target.

iii. If you do not have a Microsoft Azure profile stored on your computer, specify the following Azure parameter values for your subscription and service principal:

- **azure subscription id** The subscription ID to use for the cluster. Specify the **id** value in your account output.
- **azure tenant id** The tenant ID. Specify the **tenantId** value in your account output.
- **azure service principal client id** The value of the **appId** parameter for the service principal.
- **azure service principal client secret** The value of the **password** parameter for the service principal.

iv. Select the region to deploy the cluster to.

v. Select the base domain to deploy the cluster to. The base domain corresponds to the Azure DNS Zone that you created for your cluster.

vi. Enter a descriptive name for your cluster.

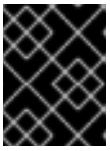
IMPORTANT

All Azure resources that are available through public endpoints are subject to resource name restrictions, and you cannot create resources that use certain terms. For a list of terms that Azure restricts, see Resolve reserved resource name errors in the Azure documentation.

vii. Paste the pull secret from the Red Hat OpenShift Cluster Manager .

2. Modify the **install-config.yaml** file. You can find more information about the available parameters in the "Installation configuration parameters" section.

3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.



IMPORTANT

The **install-config.yaml** file is consumed during the installation process. If you want to reuse the file, you must back it up now.

6.8.6.1. Installation configuration parameters

Before you deploy an OpenShift Container Platform cluster, you provide parameter values to describe your account on the cloud platform that hosts your cluster and optionally customize your cluster's platform. When you create the **install-config.yaml** installation configuration file, you provide values for the required parameters through the command line. If you customize your cluster, you can modify the **install-config.yaml** file to provide more details about the platform.

NOTE

After installation, you cannot modify these parameters in the **install-config.yaml** file.

6.8.6.1.1. Required configuration parameters

Required installation configuration parameters are described in the following table:

Table 6.19. Required parameters

Parameter	Description	Values
apiVersion	The API version for the **install-config.yaml** content. The current version is **v1**. The installer may also support older API versions.	String

Parameter	Description	Values
baseDomain	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the **baseDomain** and **metadata.name** parameter values that uses the **<metadata.name>.<baseDomain>** format.	A fully-qualified domain or subdomain name, such as **example.com**.
metadata	Kubernetes resource **ObjectMeta**, from which only the **name** parameter is consumed.	Object
metadata.name	The name of the cluster. DNS records for the cluster are all subdomains of **{{.metadata.name}}.{{.baseDomain}}**.	String of lowercase letters, hyphens (**-**), and periods (**.**), such as **dev**.
platform	The configuration for the specific platform upon which to perform the installation: **alibabacloud**, **aws**, **baremetal**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**. For additional information about **platform.<platform>** parameters, consult the table for your specific platform that follows.	Object

Parameter	Description	Values
pullSecret	Get a pull secret from the Red Hat OpenShift Cluster Manager to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	<pre>{ "auths":{ "cloud.openshift.com":{ "auth":"b3Blb=", "email":"you@example.com" }, "quay.io":{ "auth":"b3Blb=", "email":"you@example.com" } } }</pre>

6.8.6.1.2. Network configuration parameters

You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

Only IPv4 addresses are supported.

NOTE

Globalnet is not supported with Red Hat OpenShift Data Foundation disaster recovery solutions. For regional disaster recovery scenarios, ensure that you use a nonoverlapping range of private IP addresses for the cluster and service networks in each cluster.

Table 6.20. Network parameters

Parameter	Description	Values
networking	The configuration for the cluster network.	Object  **NOTE** You cannot modify parameters specified by the **networking** object after installation.

Parameter	Description	Values
networking.networkType	The cluster network provider Container Network Interface (CNI) cluster network provider to install.	Either **OpenShiftSDN** or **OVNKubernetes**. **OpenShiftSDN** is a CNI provider for all-Linux networks. **OVNKubernetes** is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is **OpenShiftSDN**.
networking.clusterNetwork	The IP address blocks for pods. The default value is **10.128.0.0/14** with a host prefix of **/23**. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: networking: clusterNetwork: - cidr: 10.128.0.0/14 hostPrefix: 23
networking.clusterNetwork.cidr	Required if you use **networking.clusterNetwork**. An IP address block. An IPv4 network.	An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between **0** and **32**.
networking.clusterNetwork.hostPrefix	The subnet prefix length to assign to each individual node. For example, if **hostPrefix** is set to **23** then each node is assigned a **/23** subnet out of the given **cidr**. A **hostPrefix** value of **23** provides 510 (2^(32 - 23) - 2) pod IP addresses.	A subnet prefix. The default value is **23**.
networking.serviceNetwork	The IP address block for services. The default value is **172.30.0.0/16**. The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.	An array with an IP address block in CIDR format. For example: networking: serviceNetwork: - 172.30.0.0/16
networking.machineNetwork	The IP address blocks for machines. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: networking: machineNetwork: - cidr: 10.0.0.0/16

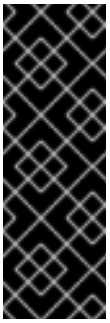
Parameter	Description	Values
networking.machineNetwork.cidr	Required if you use **networking.machineNetwork**. An IP address block. The default value is **10.0.0.0/16** for all platforms other than libvirt. For libvirt, the default value is **192.168.126.0/24**.	An IP network block in CIDR notation. For example, **10.0.0.0/16**.  **NOTE** Set the **networking.machineNetwork** to match the CIDR that the preferred NIC resides in.

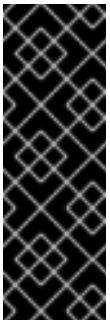
6.8.6.1.3. Optional configuration parameters

Optional installation configuration parameters are described in the following table:

Table 6.21. Optional parameters

Parameter	Description	Values
additionalTrustBundle	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String
capabilities	Controls the installation of optional core cluster components. You can reduce the footprint of your OpenShift Container Platform cluster by disabling optional components.	String array
capabilities.baselineCapabilitySet	Selects an initial set of optional capabilities to enable. Valid values are **None**, **v4.11** and **vCurrent**. **v4.11** enables the **baremetal** Operator, the **marketplace** Operator, and the **openshift-samples** content. **vCurrent** installs the recommended set of capabilities for the current version of OpenShift Container Platform. The default value is **vCurrent**.	String

Parameter	Description	Values
capabilities.additionalEnabledCapabilities	Extends the set of optional capabilities beyond what you specify in **baselineCapabilitySet**. Valid values are **baremetal**, **marketplace** and **openshift-samples**. You may specify multiple capabilities in this parameter.	String array
cgroupsV2	Enables Linux control groups version 2 (cgroups v2) on specific nodes in your cluster. The OpenShift Container Platform process for enabling cgroups v2 disables all cgroup version 1 controllers and hierarchies. The OpenShift Container Platform cgroups version 2 feature is in Developer Preview and is not supported by Red Hat at this time.	**true**
compute	The configuration for the machines that comprise the compute nodes.	Array of **MachinePool** objects.
compute.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** (the default).	String
compute.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  IMPORTANT If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
compute.name	Required if you use **compute**. The name of the machine pool.	**worker**

Parameter	Description	Values
compute.platform	Required if you use **compute**. Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the **controlPlane.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
compute.replicas	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to **2**. The default value is **3**.
controlPlane	The configuration for the machines that comprise the control plane.	Array of **MachinePool** objects.
controlPlane.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** (the default).	String
controlPlane.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  IMPORTANT If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
controlPlane.name	Required if you use **controlPlane**. The name of the machine pool.	**master**

Parameter	Description	Values
controlPlane.platform	Required if you use **controlPlane**. Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the **compute.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
controlPlane.replicas	The number of control plane machines to provision.	The only supported value is **3**, which is the default value.
credentialsMode	The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported.  **NOTE** Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the *Cloud Credential Operator* entry in the *Cluster Operators reference* content.  **NOTE** If your AWS account has service control policies (SCP) enabled, you must configure the **credentialsMode** parameter to **Mint**, **Passthrough** or **Manual**.	**Mint**, **Passthrough**, **Manual** or an empty string (**""**).

Parameter	Description	Values
fips	Enable or disable FIPS mode. The default is **false** (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.  **IMPORTANT** To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.  **NOTE** If you are using Azure File storage, you cannot enable FIPS mode.	**false** or **true**
imageContentSources	Sources and repositories for the release-image content.	Array of objects. Includes a **source** and, optionally, **mirrors**, as described in the following rows of this table.
imageContentSources.source	Required if you use **imageContentSources**. Specify the repository that users refer to, for example, in image pull specifications.	String

Parameter	Description	Values
imageContentSources.mirrors	Specify one or more repositories that may also contain the same images.	Array of strings
publish	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	**Internal** or **External**. To deploy a private cluster, which cannot be accessed from the internet, set **publish** to **Internal**. The default value is **External**.
sshKey	The SSH key to authenticate access to your cluster machines.  **NOTE** For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.	For example, **sshKey: ssh-ed25519 AAAA..**.

6.8.6.1.4. Additional Azure configuration parameters

Additional Azure configuration parameters are described in the following table.

NOTE

By default, if you specify availability zones in the **install-config.yaml** file, the installation program distributes the control plane machines and the compute machines across these availability zones within a region. To ensure high availability for your cluster, select a region with at least three availability zones. If your region contains fewer than three availability zones, the installation program places more than one control plane machine in the available zones.

Table 6.22. Additional Azure parameters

Parameter	Description	Values

Parameter	Description	Values
compute.platform.azure.encryptionAtHost	Enables host-level encryption for compute machines. You can enable this encryption alongside user-managed server-side encryption. This feature encrypts temporary, ephemeral, cached and un-managed disks on the VM host. This is not a prerequisite for user-managed server-side encryption.	**true** or **false**. The default is **false**.
compute.platform.azure.osDisk.diskSizeGB	The Azure disk size for the VM.	Integer that represents the size of the disk in GB. The default is **128**.
compute.platform.azure.osDisk.diskType	Defines the type of disk.	**standard_LRS**, **premium_LRS**, or **standardSSD_LRS**. The default is **premium_LRS**.
compute.platform.azure.ultraSSDCapability	Enables the use of Azure ultra disks for persistent storage on compute nodes. This requires that your Azure region and zone have ultra disks available.	**Enabled**, **Disabled**. The default is **Disabled**.
compute.platform.azure.osDisk.diskEncryptionSet.resourceGroup	The name of the Azure resource group that contains the disk encryption set from the installation prerequisites. This resource group should be different than the resource group where you install the cluster to avoid deleting your Azure encryption key when the cluster is destroyed. This value is only necessary if you intend to install the cluster with user-managed disk encryption.	String, for example **production_encryption_resource_group**.
compute.platform.azure.osDisk.diskEncryptionSet.name	The name of the disk encryption set that contains the encryption key from the installation prerequisites.	String, for example **production_disk_encryption_set**.
compute.platform.azure.osDisk.diskEncryptionSet.subscriptionId	Defines the Azure subscription of the disk encryption set where the disk encryption set resides. This secondary disk encryption set is used to encrypt compute machines.	String, in the format **00000000-0000-0000-0000-000000000000**.

Parameter	Description	Values
compute.platform.azure.vmNetworkingType	Enables accelerated networking. Accelerated networking enables single root I/O virtualization (SR-IOV) to a VM, improving its networking performance. If instance type of compute machines support **Accelerated** networking, by default, the installer enables **Accelerated** networking, otherwise the default networking type is **Basic**.	**Accelerated** or **Basic**.
compute.platform.azure.type	Defines the Azure instance type for compute machines.	String
compute.platform.azure.zones	The availability zones where the installation program creates compute machines.	String list
controlPlane.platform.azure.type	Defines the Azure instance type for control plane machines.	String
controlPlane.platform.azure.zones	The availability zones where the installation program creates control plane machines.	String list
platform.azure.defaultMachinePlatform.encryptionAtHost	Enables host-level encryption for compute machines. You can enable this encryption alongside user-managed server-side encryption. This feature encrypts temporary, ephemeral, cached, and un-managed disks on the VM host. This parameter is not a prerequisite for user-managed server-side encryption.	**true** or **false**. The default is **false**.
platform.azure.defaultMachinePlatform.osDisk.diskEncryptionSet.name	The name of the disk encryption set that contains the encryption key from the installation prerequisites.	String, for example, **production_disk_encryption_set**.
platform.azure.defaultMachinePlatform.osDisk.diskEncryptionSet.resourceGroup	The name of the Azure resource group that contains the disk encryption set from the installation prerequisites. To avoid deleting your Azure encryption key when the cluster is destroyed, this resource group must be different from the resource group where you install the cluster. This value is necessary only if you intend to install the cluster with user-managed disk encryption.	String, for example, **production_encryption_resource_group**.

Parameter	Description	Values
platform.azure.defaultMachinePlatform.osDisk.diskEncryptionSet.subscriptionId	Defines the Azure subscription of the disk encryption set where the disk encryption set resides. This secondary disk encryption set is used to encrypt compute machines.	String, in the format **00000000-0000-0000-0000-000000000000**.
platform.azure.defaultMachinePlatform.osDisk.diskSizeGB	The Azure disk size for the VM.	Integer that represents the size of the disk in GB. The default is **128**.
platform.azure.defaultMachinePlatform.osDisk.diskType	Defines the type of disk.	**premium_LRS** or **standardSSD_LRS**. The default is **premium_LRS**.
platform.azure.defaultMachinePlatform.type	The Azure instance type for control plane and compute machines.	The Azure instance type.
platform.azure.defaultMachinePlatform.zones	The availability zones where the installation program creates compute and control plane machines.	String list.
controlPlane.platform.azure.encryptionAtHost	Enables host-level encryption for control plane machines. You can enable this encryption alongside user-managed server-side encryption. This feature encrypts temporary, ephemeral, cached and un-managed disks on the VM host. This is not a prerequisite for user-managed server-side encryption.	**true** or **false**. The default is **false**.
controlPlane.platform.azure.osDisk.diskEncryptionSet.resourceGroup	The name of the Azure resource group that contains the disk encryption set from the installation prerequisites. This resource group should be different than the resource group where you install the cluster to avoid deleting your Azure encryption key when the cluster is destroyed. This value is only necessary if you intend to install the cluster with user-managed disk encryption.	String, for example **production_encryption_resource_group**.
controlPlane.platform.azure.osDisk.diskEncryptionSet.name	The name of the disk encryption set that contains the encryption key from the installation prerequisites.	String, for example **production_disk_encryption_set**.

Parameter	Description	Values
controlPlane.platform.azure.osDisk.diskEncryptionSet.subscriptionId	Defines the Azure subscription of the disk encryption set where the disk encryption set resides. This secondary disk encryption set is used to encrypt control plane machines.	String, in the format **00000000-0000-0000-0000-000000000000**.
controlPlane.platform.azure.osDisk.diskSizeGB	The Azure disk size for the VM.	Integer that represents the size of the disk in GB. The default is **1024**.
controlPlane.platform.azure.osDisk.diskType	Defines the type of disk.	**premium_LRS** or **standardSSD_LRS**. The default is **premium_LRS**.
controlPlane.platform.azure.ultraSSDCapability	Enables the use of Azure ultra disks for persistent storage on control plane machines. This requires that your Azure region and zone have ultra disks available.	**Enabled**, **Disabled**. The default is **Disabled**.
controlPlane.platform.azure.vmNetworkingType	Enables accelerated networking. Accelerated networking enables single root I/O virtualization (SR-IOV) to a VM, improving its networking performance. If instance type of control plane machines support **Accelerated** networking, by default, the installer enables **Accelerated** networking, otherwise the default networking type is **Basic**.	**Accelerated** or **Basic**.
platform.azure.baseDomainResourceGroupName	The name of the resource group that contains the DNS zone for your base domain.	String, for example **production_cluster**.

Parameter	Description	Values
platform.azure.resourceGroupName	The name of an already existing resource group to install your cluster to. This resource group must be empty and only used for this specific cluster; the cluster components assume ownership of all resources in the resource group. If you limit the service principal scope of the installation program to this resource group, you must ensure all other resources used by the installation program in your environment have the necessary permissions, such as the public DNS zone and virtual network. Destroying the cluster by using the installation program deletes this resource group.	String, for example **existing_resource_group**.
platform.azure.outboundType	The outbound routing strategy used to connect your cluster to the internet. If you are using user-defined routing, you must have pre-existing networking available where the outbound routing has already been configured prior to installing a cluster. The installation program is not responsible for configuring user-defined routing.	**LoadBalancer** or **UserDefinedRouting**. The default is **LoadBalancer**.
platform.azure.region	The name of the Azure region that hosts your cluster.	Any valid region name, such as **centralus**.
platform.azure.zone	List of availability zones to place machines in. For high availability, specify at least two zones.	List of zones, for example **["1", "2", "3"]**.
platform.azure.defaultMachinePlatform.ultraSSDCapability	Enables the use of Azure ultra disks for persistent storage on control plane and compute machines. This requires that your Azure region and zone have ultra disks available.	**Enabled**, **Disabled**. The default is **Disabled**.
platform.azure.networkResourceGroupName	The name of the resource group that contains the existing VNet that you want to deploy your cluster to. This name cannot be the same as the **platform.azure.baseDomainResourceGroupName**.	String.
platform.azure.virtualNetwork	The name of the existing VNet that you want to deploy your cluster to.	String.

Parameter	Description	Values
platform.azure.controlPlaneSubnet	The name of the existing subnet in your VNet that you want to deploy your control plane machines to.	Valid CIDR, for example **10.0.0.0/16**.
platform.azure.computeSubnet	The name of the existing subnet in your VNet that you want to deploy your compute machines to.	Valid CIDR, for example **10.0.0.0/16**.
platform.azure.cloudName	The name of the Azure cloud environment that is used to configure the Azure SDK with the appropriate Azure API endpoints. If empty, the default value **AzurePublicCloud** is used.	Any valid cloud environment, such as **AzurePublicCloud** or **AzureUSGovernmentCloud**.
platform.azure.defaultMachinePlatform.vmNetworkingType	Enables accelerated networking. Accelerated networking enables single root I/O virtualization (SR-IOV) to a VM, improving its networking performance.	**Accelerated** or **Basic**. If instance type of control plane and compute machines support **Accelerated** networking, by default, the installer enables **Accelerated** networking, otherwise the default networking type is **Basic**.

NOTE

You cannot customize Azure Availability Zones or Use tags to organize your Azure resources with an Azure cluster.

6.8.6.2. Minimum resource requirements for cluster installation

Each cluster machine must meet the following minimum requirements:

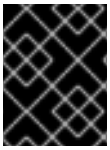
Table 6.23. Minimum resource requirements

Machine	Operating System	vCPU [1]	Virtual RAM	Storage	IOPS [2]
Bootstrap	RHCOS	4	16 GB	100 GB	300
Control plane	RHCOS	4	16 GB	100 GB	300
Compute	RHCOS, RHEL 8.6 and later [3]	2	8 GB	100 GB	300

1. One vCPU is equivalent to one physical core when simultaneous multithreading (SMT), or hyperthreading, is not enabled. When enabled, use the following formula to calculate the corresponding ratio: (threads per core × cores) × sockets = vCPUs.

2. OpenShift Container Platform and Kubernetes are sensitive to disk performance, and faster storage is recommended, particularly for etcd on the control plane nodes which require a 10 ms p99 fsync duration. Note that on many cloud platforms, storage size and IOPS scale together, so you might need to over-allocate storage volume to obtain sufficient performance.

3. As with all user-provisioned installations, if you choose to use RHEL compute machines in your cluster, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks. Use of RHEL 7 compute machines is deprecated and has been removed in OpenShift Container Platform 4.10 and later.



IMPORTANT

You are required to use Azure virtual machines that have the **premiumIO** parameter set to **true**.

If an instance type for your platform meets the minimum requirements for cluster machines, it is supported to use in OpenShift Container Platform.

Additional resources

- Optimizing storage

6.8.6.3. Tested instance types for Azure

The following Microsoft Azure instance types have been tested with OpenShift Container Platform.

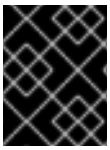
Example 6.3. Machine types

- **c4.***
- **c5.***
- **c5a.***
- **i3.***
- **m4.***
- **m5.***
- **m5a.***
- **m6a.***
- **m6i.***
- **r4.***
- **r5.***
- **r5a.***
- **r6i.***
- **t3.***

- **t3a.***

6.8.6.4. Sample customized install-config.yaml file for Azure

You can customize the **install-config.yaml** file to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.



IMPORTANT

This sample YAML file is provided for reference only. You must obtain your **install-config.yaml** file by using the installation program and modify it.

```
apiVersion: v1
baseDomain: example.com (1)
controlPlane: (2)
  hyperthreading: Enabled (3) (4)
  name: master
  platform:
    azure:
      encryptionAtHost: true
      ultraSSDCapability: Enabled
      osDisk:
        diskSizeGB: 1024 (5)
        diskType: Premium_LRS
        diskEncryptionSet:
          resourceGroup: disk_encryption_set_resource_group
          name: disk_encryption_set_name
          subscriptionId: secondary_subscription_id
      type: Standard_D8s_v3
  replicas: 3
compute: (6)
- hyperthreading: Enabled (7)
  name: worker
  platform:
    azure:
      ultraSSDCapability: Enabled
      type: Standard_D2s_v3
      encryptionAtHost: true
      osDisk:
        diskSizeGB: 512 (8)
        diskType: Standard_LRS
        diskEncryptionSet:
          resourceGroup: disk_encryption_set_resource_group
          name: disk_encryption_set_name
          subscriptionId: secondary_subscription_id
      zones: (9)
      - "1"
      - "2"
      - "3"
  replicas: 5
metadata:
  name: test-cluster (10)
```

```
networking:
  clusterNetwork:
  - cidr: 10.128.0.0/14
    hostPrefix: 23
  machineNetwork:
  - cidr: 10.0.0.0/16
  networkType: OpenShiftSDN
  serviceNetwork:
  - 172.30.0.0/16
platform:
  azure:
    defaultMachinePlatform:
      ultraSSDCapability: Enabled
    baseDomainResourceGroupName: resource_group 11
    region: centralus 12
    resourceGroupName: existing_resource_group 13
    networkResourceGroupName: vnet_resource_group 14
    virtualNetwork: vnet 15
    controlPlaneSubnet: control_plane_subnet 16
    computeSubnet: compute_subnet 17
    outboundType: Loadbalancer
    cloudName: AzurePublicCloud
pullSecret: '{"auths": ...}' 18
fips: false 19
sshKey: ssh-ed25519 AAAA... 20
```

1 10 12 18 Required. The installation program prompts you for this value.

2 6 If you do not provide these parameters and values, the installation program provides the default value.

3 7 The **controlPlane** section is a single mapping, but the **compute** section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, **-**, and the first line of the **controlPlane** section must not. Only one control plane pool is used.

4 Whether to enable or disable simultaneous multithreading, or **hyperthreading**. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores. You can disable it by setting the parameter value to **Disabled**. If you disable simultaneous multithreading in some cluster machines, you must disable it in all cluster machines.

IMPORTANT

If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance. Use larger virtual machine types, such as **Standard_D8s_v3**, for your machines if you disable simultaneous multithreading.

5 8 You can specify the size of the disk to use in GB. Minimum recommendation for control plane nodes is 1024 GB.

9 Specify a list of zones to deploy your machines to. For high availability, specify at least two zones.

11 Specify the name of the resource group that contains the DNS zone for your base domain.

13 Specify the name of an already existing resource group to install your cluster to. If undefined, a new resource group is created for the cluster.

14 If you use an existing VNet, specify the name of the resource group that contains it.

15 If you use an existing VNet, specify its name.

16 If you use an existing VNet, specify the name of the subnet to host the control plane machines.

17 If you use an existing VNet, specify the name of the subnet to host the compute machines.

19 Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.

IMPORTANT

To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.

20 You can optionally provide the **sshKey** value that you use to access the machines in your cluster.

NOTE

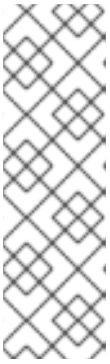
For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

6.8.6.5. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.



NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
```

1. A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
2. A proxy URL to use for creating HTTPS connections outside the cluster.
3. A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use ***** to bypass the proxy for all destinations.
4. If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace that contains one or more additional CA certificates that are required for proxying HTTPS connections. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges these contents with the Red Hat Enterprise Linux CoreOS (RHCOS) trust bundle, and this config map is referenced in the **trustedCA** field of the **Proxy** object. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.

NOTE

The installation program does not support the proxy **readinessEndpoints** field.

NOTE

If the installer times out, restart and then complete the deployment by using the **wait-for** command of the installer. For example:

```
$ ./openshift-install wait-for install-complete --log-level debug
```

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.

NOTE

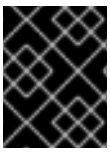
Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

Additional resources

- For more details about Accelerated Networking, see Accelerated Networking for Microsoft Azure VMs.

6.8.7. Deploying the cluster

You can install OpenShift Container Platform on a compatible cloud platform.



IMPORTANT

You can run the **create cluster** command of the installation program only once, during initial installation.

Prerequisites

- Configure an account with the cloud platform that hosts your cluster.
- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.

Procedure

- Change to the directory that contains the installation program and initialize the cluster deployment:

```
$ ./openshift-install create cluster --dir <installation_directory> \ 1
    --log-level=info 2
```

1 For **<installation_directory>**, specify the location of your customized **./install-config.yaml** file.

2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

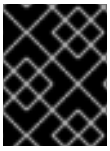
NOTE

If the cloud provider account that you configured on your host does not have sufficient permissions to deploy the cluster, the installation process stops, and the missing permissions are displayed.

Verification

When the cluster deployment completes successfully:

- The terminal displays directions for accessing your cluster, including a link to the web console and credentials for the **kubeadmin** user.
- Credential information also outputs to **<installation_directory>/.openshift_install.log**.

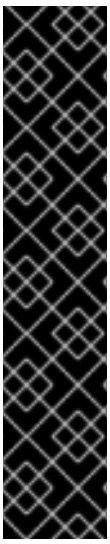


IMPORTANT

Do not delete the installation program or the files that the installation program creates. Both are required to delete the cluster.

Example output

```
...
INFO Install complete!
INFO To access the cluster as the system:admin user when using 'oc', run 'export
KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
INFO Access the OpenShift web-console here: https://console-openshift-
console.apps.mycluster.example.com
INFO Login to the console with user: "kubeadmin", and password: "password"
INFO Time elapsed: 36m22s
```



IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

6.8.8. Finalizing user-managed encryption after installation

If you installed OpenShift Container Platform using a user-managed encryption key, you can complete the installation by creating a new storage class and granting write permissions to the Azure cluster resource group.

Procedure

1. Obtain the identity of the cluster resource group used by the installer:

   a. If you specified an existing resource group in **install-config.yaml**, obtain its Azure identity by running the following command:

   ```
   $ az identity list --resource-group "<existing_resource_group>"
   ```

   b. If you did not specify a existing resource group in **install-config.yaml**, locate the resource group that the installer created, and then obtain its Azure identity by running the following commands:

   ```
   $ az group list
   ```

   ```
   $ az identity list --resource-group "<installer_created_resource_group>"
   ```

2. Grant a role assignment to the cluster resource group so that it can write to the Disk Encryption Set by running the following command:

   ```
   $ az role assignment create --role "<privileged_role>" \ 1
     --assignee "<resource_group_identity>" 2
   ```

   1 Specifies an Azure role that has read/write permissions to the disk encryption set. You can use the **Owner** role or a custom role with the necessary permissions.

   2 Specifies the identity of the cluster resource group.

3. Obtain the **id** of the disk encryption set you created prior to installation by running the following command:

   ```
   $ az disk-encryption-set show -n <disk_encryption_set_name> \ 1
     --resource-group <resource_group_name> 2
   ```

   1 Specifies the name of the disk encryption set.

   2 Specifies the resource group that contains the disk encryption set. The **id** is in the format of **"/subscriptions/.../resourceGroups/... /providers/Microsoft.Compute/diskEncryptionSets/..."**.

4. Obtain the identity of the cluster service principal by running the following command:

   ```
   $ az identity show -g <cluster_resource_group> \ 1
     -n <cluster_service_principal_name> \ 2
     --query principalId --out tsv
   ```

   1 Specifies the name of the cluster resource group created by the installation program.

   2 Specifies the name of the cluster service principal created by the installation program. The identity is in the format of **12345678-1234-1234-1234-1234567890**.

5. Create a role assignment that grants the cluster service principal **Contributor** privileges to the disk encryption set by running the following command:

```
$ az role assignment create --assignee <cluster_service_principal_id> \ 1
    --role 'Contributor' \//
    --scope <disk_encryption_set_id> \ 2
```

1 Specifies the ID of the cluster service principal obtained in the previous step.

2 Specifies the ID of the disk encryption set.

6. Create a storage class that uses the user-managed disk encryption set:

   a. Save the following storage class definition to a file, for example **storage-class-definition.yaml**:

```
kind: StorageClass
apiVersion: storage.k8s.io/v1
metadata:
  name: managed-premium
provisioner: kubernetes.io/azure-disk
parameters:
  skuname: Premium_LRS
  kind: Managed
  diskEncryptionSetID: "<disk_encryption_set_ID>" 1
  resourceGroup: "<resource_group_name>" 2
reclaimPolicy: Delete
allowVolumeExpansion: true
volumeBindingMode: WaitForFirstConsumer
```

   1 Specifies the ID of the disk encryption set that you created in the prerequisite steps, for example **"/subscriptions/xxxxxx-xxxxx-xxxxx/resourceGroups/test-encryption/providers/Microsoft.Compute/diskEncryptionSets/disk-encryption-set-xxxxxx"**.

   2 Specifies the name of the resource group used by the installer. This is the same resource group from the first step.

   b. Create the storage class **managed-premium** from the file you created by running the following command:

```
$ oc create -f storage-class-definition.yaml
```

7. Select the **managed-premium** storage class when you create persistent volumes to use encrypted storage.

6.8.9. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.

IMPORTANT

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.11. Download and install the new version of **oc**.

Installing the OpenShift CLI on Linux

You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the architecture in the **Product Variant** drop-down menu.
3. Select the appropriate version in the **Version** drop-down menu.
4. Click **Download Now** next to the **OpenShift v4.11 Linux Client** entry and save the file.
5. Unpack the archive:

```
$ tar xvf <file>
```

6. Place the **oc** binary in a directory that is on your **PATH**.
   To check your **PATH**, execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.
   To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

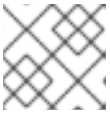
```
C:\> oc <command>
```

Installing the OpenShift CLI on macOS

You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 macOS Client** entry and save the file.



NOTE

For macOS arm64, choose the **OpenShift v4.11 macOS arm64 Client** entry.

4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your PATH.
   To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

6.8.10. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

Example output

```
system:admin
```

Additional resources

- See Accessing the web console for more details about accessing and understanding the OpenShift Container Platform web console.

6.8.11. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.11, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to OpenShift Cluster Manager Hybrid Cloud Console.

After you confirm that your OpenShift Cluster Manager Hybrid Cloud Console inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, use subscription watch to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

Additional resources

- See About remote health monitoring for more information about the Telemetry service

6.8.12. Next steps

- Customize your cluster.
- If necessary, you can opt out of remote health reporting .

6.9. INSTALLING A PRIVATE CLUSTER ON AZURE

In OpenShift Container Platform version 4.11, you can install a private cluster into an existing Azure Virtual Network (VNet) on Microsoft Azure. The installation program provisions the rest of the required infrastructure, which you can further customize. To customize the installation, you modify parameters in the **install-config.yaml** file before you install the cluster.

6.9.1. Prerequisites

- You reviewed details about the OpenShift Container Platform installation and update processes.
- You read the documentation on selecting a cluster installation method and preparing it for users.
- You configured an Azure account to host the cluster and determined the tested and validated region to deploy the cluster to.
- If you use a firewall, you configured it to allow the sites that your cluster requires access to.

- If the cloud identity and access management (IAM) APIs are not accessible in your environment, or if you do not want to store an administrator-level credential secret in the **kube-system** namespace, you can manually create and maintain IAM credentials.
- If you use customer-managed encryption keys, you prepared your Azure environment for encryption.

6.9.2. Private clusters

You can deploy a private OpenShift Container Platform cluster that does not expose external endpoints. Private clusters are accessible from only an internal network and are not visible to the internet.

By default, OpenShift Container Platform is provisioned to use publicly-accessible DNS and endpoints. A private cluster sets the DNS, Ingress Controller, and API server to private when you deploy your cluster. This means that the cluster resources are only accessible from your internal network and are not visible to the internet.

IMPORTANT

If the cluster has any public subnets, load balancer services created by administrators might be publicly accessible. To ensure cluster security, verify that these services are explicitly annotated as private.

To deploy a private cluster, you must:

- Use existing networking that meets your requirements. Your cluster resources might be shared between other clusters on the network.
- Deploy from a machine that has access to:
  - The API services for the cloud to which you provision.
  - The hosts on the network that you provision.
  - The internet to obtain installation media.

You can use any machine that meets these access requirements and follows your company's guidelines. For example, this machine can be a bastion host on your cloud network or a machine that has access to the network through a VPN.

6.9.2.1. Private clusters in Azure

To create a private cluster on Microsoft Azure, you must provide an existing private VNet and subnets to host the cluster. The installation program must also be able to resolve the DNS records that the cluster requires. The installation program configures the Ingress Operator and API server for only internal traffic.

Depending how your network connects to the private VNET, you might need to use a DNS forwarder to resolve the cluster's private DNS records. The cluster's machines use **168.63.129.16** internally for DNS resolution. For more information, see What is Azure Private DNS? and What is IP address 168.63.129.16? in the Azure documentation.

The cluster still requires access to internet to access the Azure APIs.

The following items are not required or created when you install a private cluster:

- A **BaseDomainResourceGroup**, since the cluster does not create public records
- Public IP addresses
- Public DNS records
- Public endpoints

> The cluster is configured so that the Operators do not create public records for the cluster and all cluster machines are placed in the private subnets that you specify.

6.9.2.1.1. Limitations

Private clusters on Azure are subject to only the limitations that are associated with the use of an existing VNet.

6.9.2.2. User-defined outbound routing

In OpenShift Container Platform, you can choose your own outbound routing for a cluster to connect to the internet. This allows you to skip the creation of public IP addresses and the public load balancer.

You can configure user-defined routing by modifying parameters in the **install-config.yaml** file before installing your cluster. A pre-existing VNet is required to use outbound routing when installing a cluster; the installation program is not responsible for configuring this.

When configuring a cluster to use user-defined routing, the installation program does not create the following resources:

- Outbound rules for access to the internet.
- Public IPs for the public load balancer.
- Kubernetes Service object to add the cluster machines to the public load balancer for outbound requests.

You must ensure the following items are available before setting user-defined routing:

- Egress to the internet is possible to pull container images, unless using an OpenShift image registry mirror.
- The cluster can access Azure APIs.
- Various allowlist endpoints are configured. You can reference these endpoints in the *Configuring your firewall* section.

There are several pre-existing networking setups that are supported for internet access using user-defined routing.

Private cluster with network address translation
You can use Azure VNET network address translation (NAT) to provide outbound internet access for the subnets in your cluster. You can reference Create a NAT gateway using Azure CLI in the Azure documentation for configuration instructions.

When using a VNet setup with Azure NAT and user-defined routing configured, you can create a private cluster with no public endpoints.

Private cluster with Azure Firewall
You can use Azure Firewall to provide outbound routing for the VNet used to install the cluster. You can learn more about providing user-defined routing with Azure Firewall in the Azure documentation.

When using a VNet setup with Azure Firewall and user-defined routing configured, you can create a private cluster with no public endpoints.

Private cluster with a proxy configuration
You can use a proxy with user-defined routing to allow egress to the internet. You must ensure that cluster Operators do not access Azure APIs using a proxy; Operators must have access to Azure APIs outside of the proxy.

When using the default route table for subnets, with **0.0.0.0/0** populated automatically by Azure, all Azure API requests are routed over Azure's internal network even though the IP addresses are public. As long as the Network Security Group rules allow egress to Azure API endpoints, proxies with user-defined routing configured allow you to create private clusters with no public endpoints.

Private cluster with no internet access
You can install a private network that restricts all access to the internet, except the Azure API. This is accomplished by mirroring the release image registry locally. Your cluster must have access to the following:

- An OpenShift image registry mirror that allows for pulling container images
- Access to Azure APIs

With these requirements available, you can use user-defined routing to create private clusters with no public endpoints.

6.9.3. About reusing a VNet for your OpenShift Container Platform cluster

In OpenShift Container Platform 4.11, you can deploy a cluster into an existing Azure Virtual Network (VNet) in Microsoft Azure. If you do, you must also use existing subnets within the VNet and routing rules.

By deploying OpenShift Container Platform into an existing Azure VNet, you might be able to avoid service limit constraints in new accounts or more easily abide by the operational constraints that your company's guidelines set. This is a good option to use if you cannot obtain the infrastructure creation permissions that are required to create the VNet.

6.9.3.1. Requirements for using your VNet

When you deploy a cluster by using an existing VNet, you must perform additional network configuration before you install the cluster. In installer-provisioned infrastructure clusters, the installer usually creates the following components, but it does not create them when you install into an existing VNet:

- Subnets
- Route tables
- VNets
- Network Security Groups

NOTE

The installation program requires that you use the cloud-provided DNS server. Using a custom DNS server is not supported and causes the installation to fail.

If you use a custom VNet, you must correctly configure it and its subnets for the installation program and the cluster to use. The installation program cannot subdivide network ranges for the cluster to use, set route tables for the subnets, or set VNet options like DHCP, so you must do so before you install the cluster.

The cluster must be able to access the resource group that contains the existing VNet and subnets. While all of the resources that the cluster creates are placed in a separate resource group that it creates, some network resources are used from a separate group. Some cluster Operators must be able to access resources in both resource groups. For example, the Machine API controller attaches NICS for the virtual machines that it creates to subnets from the networking resource group.

Your VNet must meet the following characteristics:

- The VNet's CIDR block must contain the **Networking.MachineCIDR** range, which is the IP address pool for cluster machines.
- The VNet and its subnets must belong to the same resource group, and the subnets must be configured to use Azure-assigned DHCP IP addresses instead of static IP addresses.

You must provide two subnets within your VNet, one for the control plane machines and one for the compute machines. Because Azure distributes machines in different availability zones within the region that you specify, your cluster will have high availability by default.

NOTE

By default, if you specify availability zones in the **install-config.yaml** file, the installation program distributes the control plane machines and the compute machines across these availability zones within a region. To ensure high availability for your cluster, select a region with at least three availability zones. If your region contains fewer than three availability zones, the installation program places more than one control plane machine in the available zones.

To ensure that the subnets that you provide are suitable, the installation program confirms the following data:

- All the specified subnets exist.
- There are two private subnets, one for the control plane machines and one for the compute machines.
- The subnet CIDRs belong to the machine CIDR that you specified. Machines are not provisioned in availability zones that you do not provide private subnets for.

NOTE

If you destroy a cluster that uses an existing VNet, the VNet is not deleted.

6.9.3.1.1. Network security group requirements

The network security groups for the subnets that host the compute and control plane machines require specific access to ensure that the cluster communication is correct. You must create rules to allow access to the required cluster communication ports.

IMPORTANT

The network security group rules must be in place before you install the cluster. If you attempt to install a cluster without the required access, the installation program cannot reach the Azure APIs, and installation fails.

Table 6.24. Required ports

Port	Description	Control plane	Compute
80	Allows HTTP traffic		x
443	Allows HTTPS traffic		x
6443	Allows communication to the control plane machines	x	
22623	Allows internal communication to the machine config server for provisioning machines	x	

IMPORTANT

Currently, there is no supported way to block or restrict the machine config server endpoint. The machine config server must be exposed to the network so that newly-provisioned machines, which have no existing configuration or state, are able to fetch their configuration. In this model, the root of trust is the certificate signing requests (CSR) endpoint, which is where the kubelet sends its certificate signing request for approval to join the cluster. Because of this, machine configs should not be used to distribute sensitive information, such as secrets and certificates.

To ensure that the machine config server endpoints, ports 22623 and 22624, are secured in bare metal scenarios, customers must configure proper network policies.

Because cluster components do not modify the user-provided network security groups, which the Kubernetes controllers update, a pseudo-network security group is created for the Kubernetes controller to modify without impacting the rest of the environment.

Additional resources

- About the OpenShift SDN network plugin

6.9.3.2. Division of permissions

Starting with OpenShift Container Platform 4.3, you do not need all of the permissions that are required for an installation program-provisioned infrastructure cluster to deploy a cluster. This change mimics the division of permissions that you might have at your company: some individuals can create different resources in your clouds than others. For example, you might be able to create application-specific items, like instances, storage, and load balancers, but not networking-related components such as VNets, subnet, or ingress rules.

The Azure credentials that you use when you create your cluster do not need the networking permissions that are required to make VNets and core networking components within the VNet, such as subnets, routing tables, internet gateways, NAT, and VPN. You still need permission to make the application resources that the machines within the cluster require, such as load balancers, security groups, storage accounts, and nodes.

6.9.3.3. Isolation between clusters

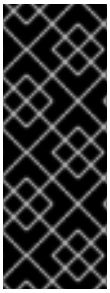
Because the cluster is unable to modify network security groups in an existing subnet, there is no way to isolate clusters from each other on the VNet.

6.9.4. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.11, you require access to the internet to install your cluster.

You must have internet access to:

- Access OpenShift Cluster Manager Hybrid Cloud Console to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access Quay.io to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.



IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

6.9.5. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the **~/.ssh/authorized_keys** list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The **./openshift-install gather** command also requires the SSH public key to be in place on the cluster nodes.

IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.

NOTE

You must use a local key, not one that you configured with platform-specific approaches such as AWS key pairs.

Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N '' -f <path>/<file_name> 1
```

1 Specify the path and file name, such as ~/**.ssh/id_ed25519**, of the new SSH key. If you have an existing key pair, ensure your public key is in the your ~/**.ssh** directory.

NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS validated or Modules In Process cryptographic libraries on the **x86_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

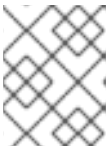
2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the ~/**.ssh/id_ed25519.pub** public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the **./openshift-install gather** command.



NOTE

On some distributions, default SSH private key identities such as ~/**.ssh/id_rsa** and ~/**.ssh/id_dsa** are managed automatically.

a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

Example output

```
Agent pid 31874
```

NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

1 Specify the path and file name for your SSH private key, such as **~/.ssh/id_ed25519**

Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

6.9.6. Obtaining the installation program

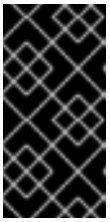
Before you install OpenShift Container Platform, download the installation file on a local computer.

Prerequisites

- You have a computer that runs Linux or macOS, with 500 MB of local disk space.

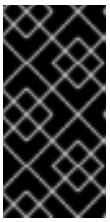
Procedure

1. Access the Infrastructure Provider page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program that corresponds with your host operating system and architecture, and place the file in the directory where you will store the installation configuration files.



IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.



IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation pull secret from the Red Hat OpenShift Cluster Manager . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

6.9.7. Manually creating the installation configuration file

For installations of a private OpenShift Container Platform cluster that are only accessible from an internal network and are not visible to the internet, you must manually generate your installation configuration file.

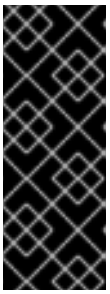
Prerequisites

- You have an SSH public key on your local machine to provide to the installation program. The key will be used for SSH authentication onto your cluster nodes for debugging and disaster recovery.
- You have obtained the OpenShift Container Platform installation program and the pull secret for your cluster.

Procedure

1. Create an installation directory to store your required installation assets in:

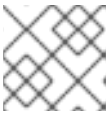
```
$ mkdir <installation_directory>
```



IMPORTANT

You must create a directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

2. Customize the sample **install-config.yaml** file template that is provided and save it in the **<installation_directory>**.



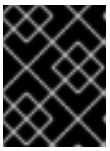
NOTE

You must name this configuration file **install-config.yaml**.

NOTE

For some platform types, you can alternatively run **./openshift-install create install-config --dir <installation_directory>** to generate an **install-config.yaml** file. You can provide details about your cluster configuration at the prompts.

3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.



IMPORTANT

The **install-config.yaml** file is consumed during the next step of the installation process. You must back it up now.

6.9.7.1. Installation configuration parameters

Before you deploy an OpenShift Container Platform cluster, you provide parameter values to describe your account on the cloud platform that hosts your cluster and optionally customize your cluster's platform. When you create the **install-config.yaml** installation configuration file, you provide values for the required parameters through the command line. If you customize your cluster, you can modify the **install-config.yaml** file to provide more details about the platform.

NOTE

After installation, you cannot modify these parameters in the **install-config.yaml** file.

6.9.7.1.1. Required configuration parameters

Required installation configuration parameters are described in the following table:

Table 6.25. Required parameters

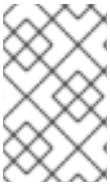
Parameter	Description	Values
apiVersion	The API version for the **install-config.yaml** content. The current version is **v1**. The installer may also support older API versions.	String
baseDomain	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the **baseDomain** and **metadata.name** parameter values that uses the **<metadata.name>.<baseDomain>** format.	A fully-qualified domain or subdomain name, such as **example.com**.
metadata	Kubernetes resource **ObjectMeta**, from which only the **name** parameter is consumed.	Object

Parameter	Description	Values
metadata.name	The name of the cluster. DNS records for the cluster are all subdomains of **{{.metadata.name}}.{{.baseDomain}}**.	String of lowercase letters, hyphens (**-**), and periods (**.**), such as **dev**.
platform	The configuration for the specific platform upon which to perform the installation: **alibabacloud**, **aws**, **baremetal**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**. For additional information about **platform.<platform>** parameters, consult the table for your specific platform that follows.	Object
pullSecret	Get a pull secret from the Red Hat OpenShift Cluster Manager to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	{ "auths":{ "cloud.openshift.com":{ "auth":"b3Blb=", "email":"you@example.com" }, "quay.io":{ "auth":"b3Blb=", "email":"you@example.com" } } }

6.9.7.1.2. Network configuration parameters

You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

Only IPv4 addresses are supported.



NOTE

Globalnet is not supported with Red Hat OpenShift Data Foundation disaster recovery solutions. For regional disaster recovery scenarios, ensure that you use a nonoverlapping range of private IP addresses for the cluster and service networks in each cluster.

Table 6.26. Network parameters

Parameter	Description	Values
networking	The configuration for the cluster network.	Object  **NOTE** You cannot modify parameters specified by the **networking** object after installation.
networking.networkType	The cluster network provider Container Network Interface (CNI) cluster network provider to install.	Either **OpenShiftSDN** or **OVNKubernetes**. **OpenShiftSDN** is a CNI provider for all-Linux networks. **OVNKubernetes** is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is **OpenShiftSDN**.
networking.clusterNetwork	The IP address blocks for pods. The default value is **10.128.0.0/14** with a host prefix of **/23**. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: `networking:` `  clusterNetwork:` `  - cidr: 10.128.0.0/14` `    hostPrefix: 23`
networking.clusterNetwork.cidr	Required if you use **networking.clusterNetwork**. An IP address block. An IPv4 network.	An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between **0** and **32**.
networking.clusterNetwork.hostPrefix	The subnet prefix length to assign to each individual node. For example, if **hostPrefix** is set to **23** then each node is assigned a **/23** subnet out of the given **cidr**. A **hostPrefix** value of **23** provides 510 (2^(32 - 23) - 2) pod IP addresses.	A subnet prefix. The default value is **23**.
networking.serviceNetwork	The IP address block for services. The default value is **172.30.0.0/16**. The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.	An array with an IP address block in CIDR format. For example: `networking:` `  serviceNetwork:` `  - 172.30.0.0/16`

Parameter	Description	Values
networking.machineNetwork	The IP address blocks for machines. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: networking: machineNetwork: - cidr: 10.0.0.0/16
networking.machineNetwork.cidr	Required if you use **networking.machineNetwork**. An IP address block. The default value is **10.0.0.0/16** for all platforms other than libvirt. For libvirt, the default value is **192.168.126.0/24**.	An IP network block in CIDR notation. For example, **10.0.0.0/16**. NOTE Set the **networking.machineNetwork** to match the CIDR that the preferred NIC resides in.

6.9.7.1.3. Optional configuration parameters

Optional installation configuration parameters are described in the following table:

Table 6.27. Optional parameters

Parameter	Description	Values
additionalTrustBundle	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String
capabilities	Controls the installation of optional core cluster components. You can reduce the footprint of your OpenShift Container Platform cluster by disabling optional components.	String array

Parameter	Description	Values
capabilities.baselineCapabilitySet	Selects an initial set of optional capabilities to enable. Valid values are **None**, **v4.11** and **vCurrent**. **v4.11** enables the **baremetal** Operator, the **marketplace** Operator, and the **openshift-samples** content. **vCurrent** installs the recommended set of capabilities for the current version of OpenShift Container Platform. The default value is **vCurrent**.	String
capabilities.additionalEnabledCapabilities	Extends the set of optional capabilities beyond what you specify in **baselineCapabilitySet**. Valid values are **baremetal**, **marketplace** and **openshift-samples**. You may specify multiple capabilities in this parameter.	String array
cgroupsV2	Enables Linux control groups version 2 (cgroups v2) on specific nodes in your cluster. The OpenShift Container Platform process for enabling cgroups v2 disables all cgroup version 1 controllers and hierarchies. The OpenShift Container Platform cgroups version 2 feature is in Developer Preview and is not supported by Red Hat at this time.	**true**
compute	The configuration for the machines that comprise the compute nodes.	Array of **MachinePool** objects.
compute.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** (the default).	String

Parameter	Description	Values
compute.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  **IMPORTANT** If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
compute.name	Required if you use **compute**. The name of the machine pool.	**worker**
compute.platform	Required if you use **compute**. Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the **controlPlane.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
compute.replicas	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to **2**. The default value is **3**.
controlPlane	The configuration for the machines that comprise the control plane.	Array of **MachinePool** objects.
controlPlane.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** (the default).	String

Parameter	Description	Values
controlPlane.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  **IMPORTANT** If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
controlPlane.name	Required if you use **controlPlane**. The name of the machine pool.	**master**
controlPlane.platform	Required if you use **controlPlane**. Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the **compute.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
controlPlane.replicas	The number of control plane machines to provision.	The only supported value is **3**, which is the default value.

Parameter	Description	Values
credentialsMode	The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported.  **NOTE** Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the *Cloud Credential Operator* entry in the *Cluster Operators reference* content.  **NOTE** If your AWS account has service control policies (SCP) enabled, you must configure the **credentialsMode** parameter to **Mint**, **Passthrough** or **Manual**.	**Mint**, **Passthrough**, **Manual** or an empty string (**""**).
fips	Enable or disable FIPS mode. The default is **false** (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.	**false** or **true**

Parameter	Description	Values
	IMPORTANT  To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.  **NOTE** If you are using Azure File storage, you cannot enable FIPS mode.	
imageContentSources	Sources and repositories for the release-image content.	Array of objects. Includes a **source** and, optionally, **mirrors**, as described in the following rows of this table.
imageContentSources.source	Required if you use **imageContentSources**. Specify the repository that users refer to, for example, in image pull specifications.	String
imageContentSources.mirrors	Specify one or more repositories that may also contain the same images.	Array of strings
publish	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	**Internal** or **External**. To deploy a private cluster, which cannot be accessed from the internet, set **publish** to **Internal**. The default value is **External**.

Parameter	Description	Values
sshKey	The SSH key to authenticate access to your cluster machines. **NOTE** For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.	For example, **sshKey: ssh-ed25519 AAAA..**.

6.9.7.1.4. Additional Azure configuration parameters

Additional Azure configuration parameters are described in the following table.

NOTE

By default, if you specify availability zones in the **install-config.yaml** file, the installation program distributes the control plane machines and the compute machines across these availability zones within a region. To ensure high availability for your cluster, select a region with at least three availability zones. If your region contains fewer than three availability zones, the installation program places more than one control plane machine in the available zones.

Table 6.28. Additional Azure parameters

Parameter	Description	Values
compute.platform.azure.encryptionAtHost	Enables host-level encryption for compute machines. You can enable this encryption alongside user-managed server-side encryption. This feature encrypts temporary, ephemeral, cached and un-managed disks on the VM host. This is not a prerequisite for user-managed server-side encryption.	**true** or **false**. The default is **false**.
compute.platform.azure.osDisk.diskSizeGB	The Azure disk size for the VM.	Integer that represents the size of the disk in GB. The default is **128**.
compute.platform.azure.osDisk.diskType	Defines the type of disk.	**standard_LRS**, **premium_LRS**, or **standardSSD_LRS**. The default is **premium_LRS**.

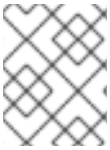
Parameter	Description	Values
compute.platform.azure.ultraSSDCapability	Enables the use of Azure ultra disks for persistent storage on compute nodes. This requires that your Azure region and zone have ultra disks available.	**Enabled**, **Disabled**. The default is **Disabled**.
compute.platform.azure.osDisk.diskEncryptionSet.resourceGroup	The name of the Azure resource group that contains the disk encryption set from the installation prerequisites. This resource group should be different than the resource group where you install the cluster to avoid deleting your Azure encryption key when the cluster is destroyed. This value is only necessary if you intend to install the cluster with user-managed disk encryption.	String, for example **production_encryption_resource_group**.
compute.platform.azure.osDisk.diskEncryptionSet.name	The name of the disk encryption set that contains the encryption key from the installation prerequisites.	String, for example **production_disk_encryption_set**.
compute.platform.azure.osDisk.diskEncryptionSet.subscriptionId	Defines the Azure subscription of the disk encryption set where the disk encryption set resides. This secondary disk encryption set is used to encrypt compute machines.	String, in the format **00000000-0000-0000-0000-000000000000**.
compute.platform.azure.vmNetworkingType	Enables accelerated networking. Accelerated networking enables single root I/O virtualization (SR-IOV) to a VM, improving its networking performance. If instance type of compute machines support **Accelerated** networking, by default, the installer enables **Accelerated** networking, otherwise the default networking type is **Basic**.	**Accelerated** or **Basic**.
compute.platform.azure.type	Defines the Azure instance type for compute machines.	String
compute.platform.azure.zones	The availability zones where the installation program creates compute machines.	String list
controlPlane.platform.azure.type	Defines the Azure instance type for control plane machines.	String

Parameter	Description	Values
controlPlane.platform.azure.zones	The availability zones where the installation program creates control plane machines.	String list
platform.azure.defaultMachinePlatform.encryptionAtHost	Enables host-level encryption for compute machines. You can enable this encryption alongside user-managed server-side encryption. This feature encrypts temporary, ephemeral, cached, and un-managed disks on the VM host. This parameter is not a prerequisite for user-managed server-side encryption.	**true** or **false**. The default is **false**.
platform.azure.defaultMachinePlatform.osDisk.diskEncryptionSet.name	The name of the disk encryption set that contains the encryption key from the installation prerequisites.	String, for example, **production_disk_encryption_set**.
platform.azure.defaultMachinePlatform.osDisk.diskEncryptionSet.resourceGroup	The name of the Azure resource group that contains the disk encryption set from the installation prerequisites. To avoid deleting your Azure encryption key when the cluster is destroyed, this resource group must be different from the resource group where you install the cluster. This value is necessary only if you intend to install the cluster with user-managed disk encryption.	String, for example, **production_encryption_resource_group**.
platform.azure.defaultMachinePlatform.osDisk.diskEncryptionSet.subscriptionId	Defines the Azure subscription of the disk encryption set where the disk encryption set resides. This secondary disk encryption set is used to encrypt compute machines.	String, in the format **00000000-0000-0000-0000-000000000000**.
platform.azure.defaultMachinePlatform.osDisk.diskSizeGB	The Azure disk size for the VM.	Integer that represents the size of the disk in GB. The default is **128**.
platform.azure.defaultMachinePlatform.osDisk.diskType	Defines the type of disk.	**premium_LRS** or **standardSSD_LRS**. The default is **premium_LRS**.
platform.azure.defaultMachinePlatform.type	The Azure instance type for control plane and compute machines.	The Azure instance type.

Parameter	Description	Values
platform.azure.defaultMachinePlatform.zones	The availability zones where the installation program creates compute and control plane machines.	String list.
controlPlane.platform.azure.encryptionAtHost	Enables host-level encryption for control plane machines. You can enable this encryption alongside user-managed server-side encryption. This feature encrypts temporary, ephemeral, cached and un-managed disks on the VM host. This is not a prerequisite for user-managed server-side encryption.	**true** or **false**. The default is **false**.
controlPlane.platform.azure.osDisk.diskEncryptionSet.resourceGroup	The name of the Azure resource group that contains the disk encryption set from the installation prerequisites. This resource group should be different than the resource group where you install the cluster to avoid deleting your Azure encryption key when the cluster is destroyed. This value is only necessary if you intend to install the cluster with user-managed disk encryption.	String, for example **production_encryption_resource_group**.
controlPlane.platform.azure.osDisk.diskEncryptionSet.name	The name of the disk encryption set that contains the encryption key from the installation prerequisites.	String, for example **production_disk_encryption_set**.
controlPlane.platform.azure.osDisk.diskEncryptionSet.subscriptionId	Defines the Azure subscription of the disk encryption set where the disk encryption set resides. This secondary disk encryption set is used to encrypt control plane machines.	String, in the format **00000000-0000-0000-0000-000000000000**.
controlPlane.platform.azure.osDisk.diskSizeGB	The Azure disk size for the VM.	Integer that represents the size of the disk in GB. The default is **1024**.
controlPlane.platform.azure.osDisk.diskType	Defines the type of disk.	**premium_LRS** or **standardSSD_LRS**. The default is **premium_LRS**.
controlPlane.platform.azure.ultraSSDCapability	Enables the use of Azure ultra disks for persistent storage on control plane machines. This requires that your Azure region and zone have ultra disks available.	**Enabled**, **Disabled**. The default is **Disabled**.

Parameter	Description	Values
controlPlane.platform.azure.vmNetworkingType	Enables accelerated networking. Accelerated networking enables single root I/O virtualization (SR-IOV) to a VM, improving its networking performance. If instance type of control plane machines support **Accelerated** networking, by default, the installer enables **Accelerated** networking, otherwise the default networking type is **Basic**.	**Accelerated** or **Basic**.
platform.azure.baseDomainResourceGroupName	The name of the resource group that contains the DNS zone for your base domain.	String, for example **production_cluster**.
platform.azure.resourceGroupName	The name of an already existing resource group to install your cluster to. This resource group must be empty and only used for this specific cluster; the cluster components assume ownership of all resources in the resource group. If you limit the service principal scope of the installation program to this resource group, you must ensure all other resources used by the installation program in your environment have the necessary permissions, such as the public DNS zone and virtual network. Destroying the cluster by using the installation program deletes this resource group.	String, for example **existing_resource_group**.
platform.azure.outboundType	The outbound routing strategy used to connect your cluster to the internet. If you are using user-defined routing, you must have pre-existing networking available where the outbound routing has already been configured prior to installing a cluster. The installation program is not responsible for configuring user-defined routing.	**LoadBalancer** or **UserDefinedRouting**. The default is **LoadBalancer**.
platform.azure.region	The name of the Azure region that hosts your cluster.	Any valid region name, such as **centralus**.
platform.azure.zone	List of availability zones to place machines in. For high availability, specify at least two zones.	List of zones, for example **["1", "2", "3"]**.

Parameter	Description	Values
platform.azure.defaultMachinePlatform.ultraSSDCapability	Enables the use of Azure ultra disks for persistent storage on control plane and compute machines. This requires that your Azure region and zone have ultra disks available.	**Enabled**, **Disabled**. The default is **Disabled**.
platform.azure.networkResourceGroupName	The name of the resource group that contains the existing VNet that you want to deploy your cluster to. This name cannot be the same as the **platform.azure.baseDomainResourceGroupName**.	String.
platform.azure.virtualNetwork	The name of the existing VNet that you want to deploy your cluster to.	String.
platform.azure.controlPlaneSubnet	The name of the existing subnet in your VNet that you want to deploy your control plane machines to.	Valid CIDR, for example **10.0.0.0/16**.
platform.azure.computeSubnet	The name of the existing subnet in your VNet that you want to deploy your compute machines to.	Valid CIDR, for example **10.0.0.0/16**.
platform.azure.cloudName	The name of the Azure cloud environment that is used to configure the Azure SDK with the appropriate Azure API endpoints. If empty, the default value **AzurePublicCloud** is used.	Any valid cloud environment, such as **AzurePublicCloud** or **AzureUSGovernmentCloud**.
platform.azure.defaultMachinePlatform.vmNetworkingType	Enables accelerated networking. Accelerated networking enables single root I/O virtualization (SR-IOV) to a VM, improving its networking performance.	**Accelerated** or **Basic**. If instance type of control plane and compute machines support **Accelerated** networking, by default, the installer enables **Accelerated** networking, otherwise the default networking type is **Basic**.



NOTE

You cannot customize Azure Availability Zones or Use tags to organize your Azure resources with an Azure cluster.

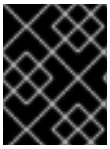
6.9.7.2. Minimum resource requirements for cluster installation

Each cluster machine must meet the following minimum requirements:

Table 6.29. Minimum resource requirements

Machine	Operating System	vCPU [1]	Virtual RAM	Storage	IOPS [2]
Bootstrap	RHCOS	4	16 GB	100 GB	300
Control plane	RHCOS	4	16 GB	100 GB	300
Compute	RHCOS, RHEL 8.6 and later [3]	2	8 GB	100 GB	300

1. One vCPU is equivalent to one physical core when simultaneous multithreading (SMT), or hyperthreading, is not enabled. When enabled, use the following formula to calculate the corresponding ratio: (threads per core × cores) × sockets = vCPUs.
2. OpenShift Container Platform and Kubernetes are sensitive to disk performance, and faster storage is recommended, particularly for etcd on the control plane nodes which require a 10 ms p99 fsync duration. Note that on many cloud platforms, storage size and IOPS scale together, so you might need to over-allocate storage volume to obtain sufficient performance.
3. As with all user-provisioned installations, if you choose to use RHEL compute machines in your cluster, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks. Use of RHEL 7 compute machines is deprecated and has been removed in OpenShift Container Platform 4.10 and later.



IMPORTANT

You are required to use Azure virtual machines that have the **premiumIO** parameter set to **true**.

If an instance type for your platform meets the minimum requirements for cluster machines, it is supported to use in OpenShift Container Platform.

Additional resources

- Optimizing storage

6.9.7.3. Tested instance types for Azure

The following Microsoft Azure instance types have been tested with OpenShift Container Platform.

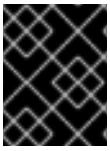
Example 6.4. Machine types

- **c4.***
- **c5.***
- **c5a.***
- **i3.***

- **m4.***
- **m5.***
- **m5a.***
- **m6a.***
- **m6i.***
- **r4.***
- **r5.***
- **r5a.***
- **r6i.***
- **t3.***
- **t3a.***

6.9.7.4. Sample customized install-config.yaml file for Azure

You can customize the **install-config.yaml** file to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.



IMPORTANT

This sample YAML file is provided for reference only. You must obtain your **install-config.yaml** file by using the installation program and modify it.

```
apiVersion: v1
baseDomain: example.com (1)
controlPlane: (2)
  hyperthreading: Enabled (3) (4)
  name: master
  platform:
    azure:
      encryptionAtHost: true
      ultraSSDCapability: Enabled
      osDisk:
        diskSizeGB: 1024 (5)
        diskType: Premium_LRS
        diskEncryptionSet:
          resourceGroup: disk_encryption_set_resource_group
          name: disk_encryption_set_name
          subscriptionId: secondary_subscription_id
      type: Standard_D8s_v3
  replicas: 3
compute: (6)
- hyperthreading: Enabled (7)
  name: worker
```

```
  platform:
    azure:
      ultraSSDCapability: Enabled
      type: Standard_D2s_v3
      encryptionAtHost: true
      osDisk:
        diskSizeGB: 512 (8)
        diskType: Standard_LRS
        diskEncryptionSet:
          resourceGroup: disk_encryption_set_resource_group
          name: disk_encryption_set_name
          subscriptionId: secondary_subscription_id
      zones: (9)
      - "1"
      - "2"
      - "3"
  replicas: 5
metadata:
  name: test-cluster (10)
networking:
  clusterNetwork:
  - cidr: 10.128.0.0/14
    hostPrefix: 23
  machineNetwork:
  - cidr: 10.0.0.0/16
  networkType: OpenShiftSDN
  serviceNetwork:
  - 172.30.0.0/16
platform:
  azure:
    defaultMachinePlatform:
      ultraSSDCapability: Enabled
    baseDomainResourceGroupName: resource_group (11)
    region: centralus (12)
    resourceGroupName: existing_resource_group (13)
    networkResourceGroupName: vnet_resource_group (14)
    virtualNetwork: vnet (15)
    controlPlaneSubnet: control_plane_subnet (16)
    computeSubnet: compute_subnet (17)
    outboundType: UserDefinedRouting (18)
    cloudName: AzurePublicCloud
pullSecret: '{"auths": ...}' (19)
fips: false (20)
sshKey: ssh-ed25519 AAAA... (21)
publish: Internal (22)
```

(1) (10) (12) (19) Required. The installation program prompts you for this value.

(2) (6) If you do not provide these parameters and values, the installation program provides the default value.

(3) (7) The **controlPlane** section is a single mapping, but the **compute** section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, **-**, and the first line of the **controlPlane** section must not. Only

one control plane pool is used.

4 Whether to enable or disable simultaneous multithreading, or **hyperthreading**. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores. You can disable it by setting the parameter value to **Disabled**. If you disable simultaneous multithreading in some cluster machines, you must disable it in all cluster machines.

IMPORTANT

If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance. Use larger virtual machine types, such as **Standard_D8s_v3**, for your machines if you disable simultaneous multithreading.

5 8 You can specify the size of the disk to use in GB. Minimum recommendation for control plane nodes is 1024 GB.

9 Specify a list of zones to deploy your machines to. For high availability, specify at least two zones.

11 Specify the name of the resource group that contains the DNS zone for your base domain.

13 Specify the name of an already existing resource group to install your cluster to. If undefined, a new resource group is created for the cluster.

14 If you use an existing VNet, specify the name of the resource group that contains it.

15 If you use an existing VNet, specify its name.

16 If you use an existing VNet, specify the name of the subnet to host the control plane machines.

17 If you use an existing VNet, specify the name of the subnet to host the compute machines.

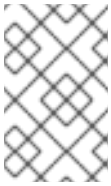
18 You can customize your own outbound routing. Configuring user-defined routing prevents exposing external endpoints in your cluster. User-defined routing for egress requires deploying your cluster to an existing VNet.

20 Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.

IMPORTANT

To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.

21 You can optionally provide the **sshKey** value that you use to access the machines in your cluster.



NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

22 How to publish the user-facing endpoints of your cluster. Set **publish** to **Internal** to deploy a private cluster, which cannot be accessed from the internet. The default value is **External**.

6.9.7.5. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.

NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
```

1 A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.

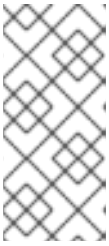
2 A proxy URL to use for creating HTTPS connections outside the cluster.

3 A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use * to bypass the proxy for all destinations.

4 If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace that contains one or more additional CA certificates that are required for proxying HTTPS connections. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges these contents with the Red Hat Enterprise Linux CoreOS (RHCOS) trust bundle, and this config map is referenced in the **trustedCA** field of the **Proxy** object. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.

NOTE

The installation program does not support the proxy **readinessEndpoints** field.



NOTE

If the installer times out, restart and then complete the deployment by using the **wait-for** command of the installer. For example:

```
$ ./openshift-install wait-for install-complete --log-level debug
```

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.

NOTE

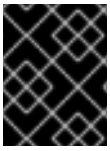
Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

Additional resources

- For more details about Accelerated Networking, see Accelerated Networking for Microsoft Azure VMs.

6.9.8. Deploying the cluster

You can install OpenShift Container Platform on a compatible cloud platform.



IMPORTANT

You can run the **create cluster** command of the installation program only once, during initial installation.

Prerequisites

- Configure an account with the cloud platform that hosts your cluster.
- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.

Procedure

- Change to the directory that contains the installation program and initialize the cluster deployment:

```
$ ./openshift-install create cluster --dir <installation_directory> \ 1
    --log-level=info 2
```

1 For **<installation_directory>**, specify the location of your customized **./install-config.yaml** file.

2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

NOTE

If the cloud provider account that you configured on your host does not have sufficient permissions to deploy the cluster, the installation process stops, and the missing permissions are displayed.

Verification

When the cluster deployment completes successfully:

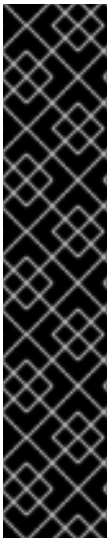
- The terminal displays directions for accessing your cluster, including a link to the web console and credentials for the **kubeadmin** user.
- Credential information also outputs to **<installation_directory>/.openshift_install.log**.

IMPORTANT

Do not delete the installation program or the files that the installation program creates. Both are required to delete the cluster.

Example output

```
...
INFO Install complete!
INFO To access the cluster as the system:admin user when using 'oc', run 'export
KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
INFO Access the OpenShift web-console here: https://console-openshift-
console.apps.mycluster.example.com
INFO Login to the console with user: "kubeadmin", and password: "password"
INFO Time elapsed: 36m22s
```



IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

6.9.9. Finalizing user-managed encryption after installation

If you installed OpenShift Container Platform using a user-managed encryption key, you can complete the installation by creating a new storage class and granting write permissions to the Azure cluster resource group.

Procedure

1. Obtain the identity of the cluster resource group used by the installer:
   a. If you specified an existing resource group in **install-config.yaml**, obtain its Azure identity by running the following command:

```
$ az identity list --resource-group "<existing_resource_group>"
```

   b. If you did not specify a existing resource group in **install-config.yaml**, locate the resource group that the installer created, and then obtain its Azure identity by running the following commands:

```
$ az group list
```

```
$ az identity list --resource-group "<installer_created_resource_group>"
```

2. Grant a role assignment to the cluster resource group so that it can write to the Disk Encryption Set by running the following command:

```
$ az role assignment create --role "<privileged_role>" \ 1
  --assignee "<resource_group_identity>" 2
```

1. Specifies an Azure role that has read/write permissions to the disk encryption set. You can use the **Owner** role or a custom role with the necessary permissions.
2. Specifies the identity of the cluster resource group.

3. Obtain the **id** of the disk encryption set you created prior to installation by running the following command:

```
$ az disk-encryption-set show -n <disk_encryption_set_name> \ 1
   --resource-group <resource_group_name> 2
```

1 Specifies the name of the disk encryption set.

2 Specifies the resource group that contains the disk encryption set. The **id** is in the format of **"/subscriptions/.../resourceGroups/... /providers/Microsoft.Compute/diskEncryptionSets/..."**.

4. Obtain the identity of the cluster service principal by running the following command:

```
$ az identity show -g <cluster_resource_group> \ 1
   -n <cluster_service_principal_name> \ 2
   --query principalId --out tsv
```

1 Specifies the name of the cluster resource group created by the installation program.

2 Specifies the name of the cluster service principal created by the installation program. The identity is in the format of **12345678-1234-1234-1234-1234567890**.

5. Create a role assignment that grants the cluster service principal **Contributor** privileges to the disk encryption set by running the following command:

```
$ az role assignment create --assignee <cluster_service_principal_id> \ 1
   --role 'Contributor' \//
   --scope <disk_encryption_set_id> \ 2
```

1 Specifies the ID of the cluster service principal obtained in the previous step.

2 Specifies the ID of the disk encryption set.

6. Create a storage class that uses the user-managed disk encryption set:

   a. Save the following storage class definition to a file, for example **storage-class-definition.yaml**:

```
kind: StorageClass
apiVersion: storage.k8s.io/v1
metadata:
  name: managed-premium
provisioner: kubernetes.io/azure-disk
parameters:
  skuname: Premium_LRS
  kind: Managed
  diskEncryptionSetID: "<disk_encryption_set_ID>" 1
  resourceGroup: "<resource_group_name>" 2
reclaimPolicy: Delete
allowVolumeExpansion: true
volumeBindingMode: WaitForFirstConsumer
```

1. Specifies the ID of the disk encryption set that you created in the prerequisite steps, for example **"/subscriptions/xxxxxx-xxxxx-xxxxx/resourceGroups/test-**
2. Specifies the name of the resource group used by the installer. This is the same resource group from the first step.

b. Create the storage class **managed-premium** from the file you created by running the following command:

```
$ oc create -f storage-class-definition.yaml
```

7. Select the **managed-premium** storage class when you create persistent volumes to use encrypted storage.

6.9.10. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.

IMPORTANT

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.11. Download and install the new version of **oc**.

Installing the OpenShift CLI on Linux

You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the architecture in the **Product Variant** drop-down menu.
3. Select the appropriate version in the **Version** drop-down menu.
4. Click **Download Now** next to the **OpenShift v4.11 Linux Client** entry and save the file.
5. Unpack the archive:

```
$ tar xvf <file>
```

6. Place the **oc** binary in a directory that is on your **PATH**.
   To check your **PATH**, execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.
   To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
C:\> oc <command>
```

Installing the OpenShift CLI on macOS

You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 macOS Client** entry and save the file.

NOTE

For macOS arm64, choose the **OpenShift v4.11 macOS arm64 Client** entry.

4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your PATH.
   To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

6.9.11. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

Example output

```
system:admin
```

Additional resources

- See Accessing the web console for more details about accessing and understanding the OpenShift Container Platform web console.

6.9.12. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.11, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to OpenShift Cluster Manager Hybrid Cloud Console.

After you confirm that your OpenShift Cluster Manager Hybrid Cloud Console inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, use subscription watch to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

Additional resources

- See About remote health monitoring for more information about the Telemetry service

6.9.13. Next steps

- Customize your cluster.
- If necessary, you can opt out of remote health reporting .

6.10. INSTALLING A CLUSTER ON AZURE INTO A GOVERNMENT REGION

In OpenShift Container Platform version 4.11, you can install a cluster on Microsoft Azure into a government region. To configure the government region, you modify parameters in the **install-config.yaml** file before you install the cluster.

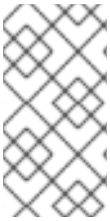
6.10.1. Prerequisites

- You reviewed details about the OpenShift Container Platform installation and update processes.
- You read the documentation on selecting a cluster installation method and preparing it for users.
- You configured an Azure account to host the cluster and determined the tested and validated government region to deploy the cluster to.
- If you use a firewall, you configured it to allow the sites that your cluster requires access to.
- If the cloud identity and access management (IAM) APIs are not accessible in your environment, or if you do not want to store an administrator-level credential secret in the **kube-system** namespace, you can manually create and maintain IAM credentials.
- If you use customer-managed encryption keys, you prepared your Azure environment for encryption.

6.10.2. Azure government regions

OpenShift Container Platform supports deploying a cluster to Microsoft Azure Government (MAG) regions. MAG is specifically designed for US government agencies at the federal, state, and local level, as well as contractors, educational institutions, and other US customers that must run sensitive workloads on Azure. MAG is composed of government-only data center regions, all granted an Impact Level 5 Provisional Authorization.

Installing to a MAG region requires manually configuring the Azure Government dedicated cloud instance and region in the **install-config.yaml** file. You must also update your service principal to reference the appropriate government environment.



NOTE

The Azure government region cannot be selected using the guided terminal prompts from the installation program. You must define the region manually in the **install-config.yaml** file. Remember to also set the dedicated cloud instance, like **AzureUSGovernmentCloud**, based on the region specified.

6.10.3. Private clusters

You can deploy a private OpenShift Container Platform cluster that does not expose external endpoints. Private clusters are accessible from only an internal network and are not visible to the internet.

By default, OpenShift Container Platform is provisioned to use publicly-accessible DNS and endpoints. A private cluster sets the DNS, Ingress Controller, and API server to private when you deploy your cluster. This means that the cluster resources are only accessible from your internal network and are not visible to the internet.

IMPORTANT

If the cluster has any public subnets, load balancer services created by administrators might be publicly accessible. To ensure cluster security, verify that these services are explicitly annotated as private.

To deploy a private cluster, you must:

- Use existing networking that meets your requirements. Your cluster resources might be shared between other clusters on the network.
- Deploy from a machine that has access to:
  - The API services for the cloud to which you provision.
  - The hosts on the network that you provision.
  - The internet to obtain installation media.

You can use any machine that meets these access requirements and follows your company's guidelines. For example, this machine can be a bastion host on your cloud network or a machine that has access to the network through a VPN.

6.10.3.1. Private clusters in Azure

To create a private cluster on Microsoft Azure, you must provide an existing private VNet and subnets to host the cluster. The installation program must also be able to resolve the DNS records that the cluster requires. The installation program configures the Ingress Operator and API server for only internal traffic.

Depending how your network connects to the private VNET, you might need to use a DNS forwarder to resolve the cluster's private DNS records. The cluster's machines use **168.63.129.16** internally for DNS resolution. For more information, see What is Azure Private DNS? and What is IP address 168.63.129.16? in the Azure documentation.

The cluster still requires access to internet to access the Azure APIs.

The following items are not required or created when you install a private cluster:

- A **BaseDomainResourceGroup**, since the cluster does not create public records
- Public IP addresses
- Public DNS records
- Public endpoints

> The cluster is configured so that the Operators do not create public records for the cluster and all cluster machines are placed in the private subnets that you specify.

6.10.3.1.1. Limitations

Private clusters on Azure are subject to only the limitations that are associated with the use of an existing VNet.

6.10.3.2. User-defined outbound routing

In OpenShift Container Platform, you can choose your own outbound routing for a cluster to connect to the internet. This allows you to skip the creation of public IP addresses and the public load balancer.

You can configure user-defined routing by modifying parameters in the **install-config.yaml** file before installing your cluster. A pre-existing VNet is required to use outbound routing when installing a cluster; the installation program is not responsible for configuring this.

When configuring a cluster to use user-defined routing, the installation program does not create the following resources:

- Outbound rules for access to the internet.
- Public IPs for the public load balancer.
- Kubernetes Service object to add the cluster machines to the public load balancer for outbound requests.

You must ensure the following items are available before setting user-defined routing:

- Egress to the internet is possible to pull container images, unless using an OpenShift image registry mirror.
- The cluster can access Azure APIs.
- Various allowlist endpoints are configured. You can reference these endpoints in the *Configuring your firewall* section.

There are several pre-existing networking setups that are supported for internet access using user-defined routing.

Private cluster with network address translation
You can use Azure VNET network address translation (NAT) to provide outbound internet access for the subnets in your cluster. You can reference Create a NAT gateway using Azure CLI in the Azure documentation for configuration instructions.

When using a VNet setup with Azure NAT and user-defined routing configured, you can create a private cluster with no public endpoints.

Private cluster with Azure Firewall
You can use Azure Firewall to provide outbound routing for the VNet used to install the cluster. You can learn more about providing user-defined routing with Azure Firewall in the Azure documentation.

When using a VNet setup with Azure Firewall and user-defined routing configured, you can create a private cluster with no public endpoints.

Private cluster with a proxy configuration

You can use a proxy with user-defined routing to allow egress to the internet. You must ensure that cluster Operators do not access Azure APIs using a proxy; Operators must have access to Azure APIs outside of the proxy.

When using the default route table for subnets, with **0.0.0.0/0** populated automatically by Azure, all Azure API requests are routed over Azure's internal network even though the IP addresses are public. As long as the Network Security Group rules allow egress to Azure API endpoints, proxies with user-defined routing configured allow you to create private clusters with no public endpoints.

Private cluster with no internet access
You can install a private network that restricts all access to the internet, except the Azure API. This is accomplished by mirroring the release image registry locally. Your cluster must have access to the following:

- An OpenShift image registry mirror that allows for pulling container images
- Access to Azure APIs

With these requirements available, you can use user-defined routing to create private clusters with no public endpoints.

6.10.4. About reusing a VNet for your OpenShift Container Platform cluster

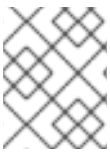
In OpenShift Container Platform 4.11, you can deploy a cluster into an existing Azure Virtual Network (VNet) in Microsoft Azure. If you do, you must also use existing subnets within the VNet and routing rules.

By deploying OpenShift Container Platform into an existing Azure VNet, you might be able to avoid service limit constraints in new accounts or more easily abide by the operational constraints that your company's guidelines set. This is a good option to use if you cannot obtain the infrastructure creation permissions that are required to create the VNet.

6.10.4.1. Requirements for using your VNet

When you deploy a cluster by using an existing VNet, you must perform additional network configuration before you install the cluster. In installer-provisioned infrastructure clusters, the installer usually creates the following components, but it does not create them when you install into an existing VNet:

- Subnets
- Route tables
- VNets
- Network Security Groups



NOTE

The installation program requires that you use the cloud-provided DNS server. Using a custom DNS server is not supported and causes the installation to fail.

If you use a custom VNet, you must correctly configure it and its subnets for the installation program and the cluster to use. The installation program cannot subdivide network ranges for the cluster to use, set route tables for the subnets, or set VNet options like DHCP, so you must do so before you install the cluster.

The cluster must be able to access the resource group that contains the existing VNet and subnets. While all of the resources that the cluster creates are placed in a separate resource group that it creates, some network resources are used from a separate group. Some cluster Operators must be able to access resources in both resource groups. For example, the Machine API controller attaches NICS for the virtual machines that it creates to subnets from the networking resource group.

Your VNet must meet the following characteristics:

- The VNet's CIDR block must contain the **Networking.MachineCIDR** range, which is the IP address pool for cluster machines.
- The VNet and its subnets must belong to the same resource group, and the subnets must be configured to use Azure-assigned DHCP IP addresses instead of static IP addresses.

You must provide two subnets within your VNet, one for the control plane machines and one for the compute machines. Because Azure distributes machines in different availability zones within the region that you specify, your cluster will have high availability by default.

NOTE

By default, if you specify availability zones in the **install-config.yaml** file, the installation program distributes the control plane machines and the compute machines across these availability zones within a region. To ensure high availability for your cluster, select a region with at least three availability zones. If your region contains fewer than three availability zones, the installation program places more than one control plane machine in the available zones.

To ensure that the subnets that you provide are suitable, the installation program confirms the following data:

- All the specified subnets exist.
- There are two private subnets, one for the control plane machines and one for the compute machines.
- The subnet CIDRs belong to the machine CIDR that you specified. Machines are not provisioned in availability zones that you do not provide private subnets for. If required, the installation program creates public load balancers that manage the control plane and worker nodes, and Azure allocates a public IP address to them.

NOTE

If you destroy a cluster that uses an existing VNet, the VNet is not deleted.

6.10.4.1.1. Network security group requirements

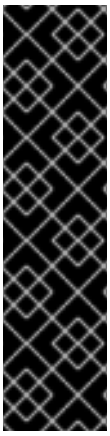
The network security groups for the subnets that host the compute and control plane machines require specific access to ensure that the cluster communication is correct. You must create rules to allow access to the required cluster communication ports.

IMPORTANT

The network security group rules must be in place before you install the cluster. If you attempt to install a cluster without the required access, the installation program cannot reach the Azure APIs, and installation fails.

Table 6.30. Required ports

Port	Description	Control plane	Compute
80	Allows HTTP traffic		x
443	Allows HTTPS traffic		x
6443	Allows communication to the control plane machines	x	
22623	Allows internal communication to the machine config server for provisioning machines	x	



IMPORTANT

Currently, there is no supported way to block or restrict the machine config server endpoint. The machine config server must be exposed to the network so that newly-provisioned machines, which have no existing configuration or state, are able to fetch their configuration. In this model, the root of trust is the certificate signing requests (CSR) endpoint, which is where the kubelet sends its certificate signing request for approval to join the cluster. Because of this, machine configs should not be used to distribute sensitive information, such as secrets and certificates.

To ensure that the machine config server endpoints, ports 22623 and 22624, are secured in bare metal scenarios, customers must configure proper network policies.

Because cluster components do not modify the user-provided network security groups, which the Kubernetes controllers update, a pseudo-network security group is created for the Kubernetes controller to modify without impacting the rest of the environment.

Additional resources

- About the OpenShift SDN network plugin

6.10.4.2. Division of permissions

Starting with OpenShift Container Platform 4.3, you do not need all of the permissions that are required for an installation program-provisioned infrastructure cluster to deploy a cluster. This change mimics the division of permissions that you might have at your company: some individuals can create different resources in your clouds than others. For example, you might be able to create application-specific items, like instances, storage, and load balancers, but not networking-related components such as VNets, subnet, or ingress rules.

The Azure credentials that you use when you create your cluster do not need the networking permissions that are required to make VNets and core networking components within the VNet, such as subnets, routing tables, internet gateways, NAT, and VPN. You still need permission to make the application resources that the machines within the cluster require, such as load balancers, security groups, storage accounts, and nodes.

6.10.4.3. Isolation between clusters

Because the cluster is unable to modify network security groups in an existing subnet, there is no way to isolate clusters from each other on the VNet.

6.10.5. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.11, you require access to the internet to install your cluster.

You must have internet access to:

- Access OpenShift Cluster Manager Hybrid Cloud Console to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access Quay.io to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.

IMPORTANT

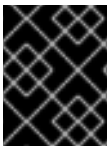
If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

6.10.6. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the **~/.ssh/authorized_keys** list for the **core** user on each node, which enables password-less authentication.

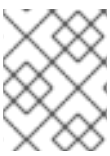
After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The **./openshift-install gather** command also requires the SSH public key to be in place on the cluster nodes.



IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.



NOTE

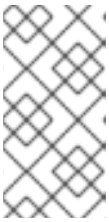
You must use a local key, not one that you configured with platform-specific approaches such as AWS key pairs.

Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N '' -f <path>/<file_name> 1
```

1 Specify the path and file name, such as ~/**.ssh/id_ed25519**, of the new SSH key. If you have an existing key pair, ensure your public key is in the your ~/**.ssh** directory.



NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS validated or Modules In Process cryptographic libraries on the **x86_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the ~/**.ssh/id_ed25519.pub** public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the **./openshift-install gather** command.

NOTE

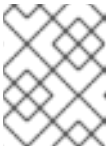
On some distributions, default SSH private key identities such as ~/**.ssh/id_rsa** and ~/**.ssh/id_dsa** are managed automatically.

a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

Example output

```
Agent pid 31874
```



NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

1 Specify the path and file name for your SSH private key, such as **~/.ssh/id_ed25519**

Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

6.10.7. Obtaining the installation program

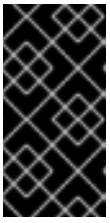
Before you install OpenShift Container Platform, download the installation file on a local computer.

Prerequisites

- You have a computer that runs Linux or macOS, with 500 MB of local disk space.

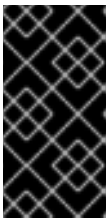
Procedure

1. Access the Infrastructure Provider page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program that corresponds with your host operating system and architecture, and place the file in the directory where you will store the installation configuration files.



IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.



IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation pull secret from the Red Hat OpenShift Cluster Manager . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform

components.

6.10.8. Manually creating the installation configuration file

When installing OpenShift Container Platform on Microsoft Azure into a government region, you must manually generate your installation configuration file.

Prerequisites

- You have an SSH public key on your local machine to provide to the installation program. The key will be used for SSH authentication onto your cluster nodes for debugging and disaster recovery.
- You have obtained the OpenShift Container Platform installation program and the pull secret for your cluster.

Procedure

1. Create an installation directory to store your required installation assets in:

```
$ mkdir <installation_directory>
```

IMPORTANT

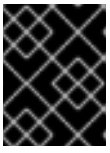
You must create a directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

2. Customize the sample **install-config.yaml** file template that is provided and save it in the **<installation_directory>**.

NOTE

You must name this configuration file **install-config.yaml**.

3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.



IMPORTANT

The **install-config.yaml** file is consumed during the next step of the installation process. You must back it up now.

6.10.8.1. Installation configuration parameters

Before you deploy an OpenShift Container Platform cluster, you provide parameter values to describe your account on the cloud platform that hosts your cluster and optionally customize your cluster's platform. When you create the **install-config.yaml** installation configuration file, you provide values for the required parameters through the command line. If you customize your cluster, you can modify the **install-config.yaml** file to provide more details about the platform.

NOTE

After installation, you cannot modify these parameters in the **install-config.yaml** file.

6.10.8.1.1. Required configuration parameters

Required installation configuration parameters are described in the following table:

Table 6.31. Required parameters

Parameter	Description	Values
apiVersion	The API version for the **install-config.yaml** content. The current version is **v1**. The installer may also support older API versions.	String
baseDomain	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the **baseDomain** and **metadata.name** parameter values that uses the **<metadata.name>.<baseDomain>** format.	A fully-qualified domain or subdomain name, such as **example.com**.
metadata	Kubernetes resource **ObjectMeta**, from which only the **name** parameter is consumed.	Object
metadata.name	The name of the cluster. DNS records for the cluster are all subdomains of **{{.metadata.name}}.{{.baseDomain}}**.	String of lowercase letters, hyphens (**-**), and periods (**.**), such as **dev**.

Parameter	Description	Values
platform	The configuration for the specific platform upon which to perform the installation: **alibabacloud**, **aws**, **baremetal**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**. For additional information about **platform.<platform>** parameters, consult the table for your specific platform that follows.	Object
pullSecret	Get a pull secret from the Red Hat OpenShift Cluster Manager to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	<pre>{ "auths":{ "cloud.openshift.com":{ "auth":"b3Blb=", "email":"you@example.com" }, "quay.io":{ "auth":"b3Blb=", "email":"you@example.com" } } }</pre>

6.10.8.1.2. Network configuration parameters

You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

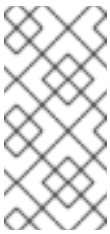
Only IPv4 addresses are supported.

NOTE

Globalnet is not supported with Red Hat OpenShift Data Foundation disaster recovery solutions. For regional disaster recovery scenarios, ensure that you use a nonoverlapping range of private IP addresses for the cluster and service networks in each cluster.

Table 6.32. Network parameters

Parameter	Description	Values

Parameter	Description	Values
networking	The configuration for the cluster network.	Object  **NOTE** You cannot modify parameters specified by the **networking** object after installation.
networking.networkType	The cluster network provider Container Network Interface (CNI) cluster network provider to install.	Either **OpenShiftSDN** or **OVNKubernetes**. **OpenShiftSDN** is a CNI provider for all-Linux networks. **OVNKubernetes** is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is **OpenShiftSDN**.
networking.clusterNetwork	The IP address blocks for pods. The default value is **10.128.0.0/14** with a host prefix of **/23**. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: `networking:` `  clusterNetwork:` `  - cidr: 10.128.0.0/14` `    hostPrefix: 23`
networking.clusterNetwork.cidr	Required if you use **networking.clusterNetwork**. An IP address block. An IPv4 network.	An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between **0** and **32**.
networking.clusterNetwork.hostPrefix	The subnet prefix length to assign to each individual node. For example, if **hostPrefix** is set to **23** then each node is assigned a **/23** subnet out of the given **cidr**. A **hostPrefix** value of **23** provides 510 (2^(32 - 23) - 2) pod IP addresses.	A subnet prefix. The default value is **23**.
networking.serviceNetwork	The IP address block for services. The default value is **172.30.0.0/16**. The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.	An array with an IP address block in CIDR format. For example: `networking:` `  serviceNetwork:` `  - 172.30.0.0/16`

Parameter	Description	Values
networking.machineNetwork	The IP address blocks for machines. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: `networking:` `  machineNetwork:` `  - cidr: 10.0.0.0/16`
networking.machineNetwork.cidr	Required if you use **networking.machineNetwork**. An IP address block. The default value is **10.0.0.0/16** for all platforms other than libvirt. For libvirt, the default value is **192.168.126.0/24**.	An IP network block in CIDR notation. For example, **10.0.0.0/16**. **NOTE** Set the **networking.machineNetwork** to match the CIDR that the preferred NIC resides in.

6.10.8.1.3. Optional configuration parameters

Optional installation configuration parameters are described in the following table:

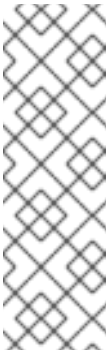
Table 6.33. Optional parameters

Parameter	Description	Values
additionalTrustBundle	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String
capabilities	Controls the installation of optional core cluster components. You can reduce the footprint of your OpenShift Container Platform cluster by disabling optional components.	String array

Parameter	Description	Values
capabilities.baselineCapabilitySet	Selects an initial set of optional capabilities to enable. Valid values are **None**, **v4.11** and **vCurrent**. **v4.11** enables the **baremetal** Operator, the **marketplace** Operator, and the **openshift-samples** content. **vCurrent** installs the recommended set of capabilities for the current version of OpenShift Container Platform. The default value is **vCurrent**.	String
capabilities.additionalEnabledCapabilities	Extends the set of optional capabilities beyond what you specify in **baselineCapabilitySet**. Valid values are **baremetal**, **marketplace** and **openshift-samples**. You may specify multiple capabilities in this parameter.	String array
cgroupsV2	Enables Linux control groups version 2 (cgroups v2) on specific nodes in your cluster. The OpenShift Container Platform process for enabling cgroups v2 disables all cgroup version 1 controllers and hierarchies. The OpenShift Container Platform cgroups version 2 feature is in Developer Preview and is not supported by Red Hat at this time.	**true**
compute	The configuration for the machines that comprise the compute nodes.	Array of **MachinePool** objects.
compute.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** (the default).	String

Parameter	Description	Values
compute.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  **IMPORTANT** If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
compute.name	Required if you use **compute**. The name of the machine pool.	**worker**
compute.platform	Required if you use **compute**. Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the **controlPlane.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
compute.replicas	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to **2**. The default value is **3**.
controlPlane	The configuration for the machines that comprise the control plane.	Array of **MachinePool** objects.
controlPlane.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** (the default).	String

Parameter	Description	Values
controlPlane.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  **IMPORTANT** If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
controlPlane.name	Required if you use **controlPlane**. The name of the machine pool.	**master**
controlPlane.platform	Required if you use **controlPlane**. Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the **compute.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
controlPlane.replicas	The number of control plane machines to provision.	The only supported value is **3**, which is the default value.

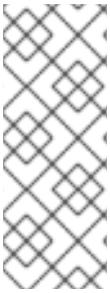
Parameter	Description	Values
credentialsMode	The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported.  **NOTE** Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the *Cloud Credential Operator* entry in the *Cluster Operators reference* content.  **NOTE** If your AWS account has service control policies (SCP) enabled, you must configure the **credentialsMode** parameter to **Mint**, **Passthrough** or **Manual**.	**Mint**, **Passthrough**, **Manual** or an empty string (**""**).
fips	Enable or disable FIPS mode. The default is **false** (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.	**false** or **true**

Parameter	Description	Values
	IMPORTANT  To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.  NOTE If you are using Azure File storage, you cannot enable FIPS mode.	
imageContentSources	Sources and repositories for the release-image content.	Array of objects. Includes a **source** and, optionally, **mirrors**, as described in the following rows of this table.
imageContentSources.source	Required if you use **imageContentSources**. Specify the repository that users refer to, for example, in image pull specifications.	String
imageContentSources.mirrors	Specify one or more repositories that may also contain the same images.	Array of strings

Parameter	Description	Values
publish	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	**Internal** or **External**. To deploy a private cluster, which cannot be accessed from the internet, set **publish** to **Internal**. The default value is **External**.
sshKey	The SSH key to authenticate access to your cluster machines.  **NOTE** For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.	For example, **sshKey: ssh-ed25519 AAAA..**.

6.10.8.1.4. Additional Azure configuration parameters

Additional Azure configuration parameters are described in the following table.



NOTE

By default, if you specify availability zones in the **install-config.yaml** file, the installation program distributes the control plane machines and the compute machines across these availability zones within a region. To ensure high availability for your cluster, select a region with at least three availability zones. If your region contains fewer than three availability zones, the installation program places more than one control plane machine in the available zones.

Table 6.34. Additional Azure parameters

Parameter	Description	Values
compute.platform.azure.encryptionAtHost	Enables host-level encryption for compute machines. You can enable this encryption alongside user-managed server-side encryption. This feature encrypts temporary, ephemeral, cached and un-managed disks on the VM host. This is not a prerequisite for user-managed server-side encryption.	**true** or **false**. The default is **false**.

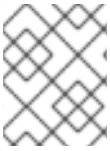
Parameter	Description	Values
compute.platform.azure.osDisk.diskSizeGB	The Azure disk size for the VM.	Integer that represents the size of the disk in GB. The default is **128**.
compute.platform.azure.osDisk.diskType	Defines the type of disk.	**standard_LRS**, **premium_LRS**, or **standardSSD_LRS**. The default is **premium_LRS**.
compute.platform.azure.ultraSSDCapability	Enables the use of Azure ultra disks for persistent storage on compute nodes. This requires that your Azure region and zone have ultra disks available.	**Enabled**, **Disabled**. The default is **Disabled**.
compute.platform.azure.osDisk.diskEncryptionSet.resourceGroup	The name of the Azure resource group that contains the disk encryption set from the installation prerequisites. This resource group should be different than the resource group where you install the cluster to avoid deleting your Azure encryption key when the cluster is destroyed. This value is only necessary if you intend to install the cluster with user-managed disk encryption.	String, for example **production_encryption_resource_group**.
compute.platform.azure.osDisk.diskEncryptionSet.name	The name of the disk encryption set that contains the encryption key from the installation prerequisites.	String, for example **production_disk_encryption_set**.
compute.platform.azure.osDisk.diskEncryptionSet.subscriptionId	Defines the Azure subscription of the disk encryption set where the disk encryption set resides. This secondary disk encryption set is used to encrypt compute machines.	String, in the format **00000000-0000-0000-0000-000000000000**.
compute.platform.azure.vmNetworkingType	Enables accelerated networking. Accelerated networking enables single root I/O virtualization (SR-IOV) to a VM, improving its networking performance. If instance type of compute machines support **Accelerated** networking, by default, the installer enables **Accelerated** networking, otherwise the default networking type is **Basic**.	**Accelerated** or **Basic**.
compute.platform.azure.type	Defines the Azure instance type for compute machines.	String

Parameter	Description	Values
compute.platform.azure.zones	The availability zones where the installation program creates compute machines.	String list
controlPlane.platform.azure.type	Defines the Azure instance type for control plane machines.	String
controlPlane.platform.azure.zones	The availability zones where the installation program creates control plane machines.	String list
platform.azure.defaultMachinePlatform.encryptionAtHost	Enables host-level encryption for compute machines. You can enable this encryption alongside user-managed server-side encryption. This feature encrypts temporary, ephemeral, cached, and un-managed disks on the VM host. This parameter is not a prerequisite for user-managed server-side encryption.	**true** or **false**. The default is **false**.
platform.azure.defaultMachinePlatform.osDisk.diskEncryptionSet.name	The name of the disk encryption set that contains the encryption key from the installation prerequisites.	String, for example, **production_disk_encryption_set**.
platform.azure.defaultMachinePlatform.osDisk.diskEncryptionSet.resourceGroup	The name of the Azure resource group that contains the disk encryption set from the installation prerequisites. To avoid deleting your Azure encryption key when the cluster is destroyed, this resource group must be different from the resource group where you install the cluster. This value is necessary only if you intend to install the cluster with user-managed disk encryption.	String, for example, **production_encryption_resource_group**.
platform.azure.defaultMachinePlatform.osDisk.diskEncryptionSet.subscriptionId	Defines the Azure subscription of the disk encryption set where the disk encryption set resides. This secondary disk encryption set is used to encrypt compute machines.	String, in the format **00000000-0000-0000-0000-000000000000**.
platform.azure.defaultMachinePlatform.osDisk.diskSizeGB	The Azure disk size for the VM.	Integer that represents the size of the disk in GB. The default is **128**.
platform.azure.defaultMachinePlatform.osDisk.diskType	Defines the type of disk.	**premium_LRS** or **standardSSD_LRS**. The default is **premium_LRS**.

Parameter	Description	Values
platform.azure.defaultMachinePlatform.type	The Azure instance type for control plane and compute machines.	The Azure instance type.
platform.azure.defaultMachinePlatform.zones	The availability zones where the installation program creates compute and control plane machines.	String list.
controlPlane.platform.azure.encryptionAtHost	Enables host-level encryption for control plane machines. You can enable this encryption alongside user-managed server-side encryption. This feature encrypts temporary, ephemeral, cached and un-managed disks on the VM host. This is not a prerequisite for user-managed server-side encryption.	**true** or **false**. The default is **false**.
controlPlane.platform.azure.osDisk.diskEncryptionSet.resourceGroup	The name of the Azure resource group that contains the disk encryption set from the installation prerequisites. This resource group should be different than the resource group where you install the cluster to avoid deleting your Azure encryption key when the cluster is destroyed. This value is only necessary if you intend to install the cluster with user-managed disk encryption.	String, for example **production_encryption_resource_group**.
controlPlane.platform.azure.osDisk.diskEncryptionSet.name	The name of the disk encryption set that contains the encryption key from the installation prerequisites.	String, for example **production_disk_encryption_set**.
controlPlane.platform.azure.osDisk.diskEncryptionSet.subscriptionId	Defines the Azure subscription of the disk encryption set where the disk encryption set resides. This secondary disk encryption set is used to encrypt control plane machines.	String, in the format **00000000-0000-0000-0000-000000000000**.
controlPlane.platform.azure.osDisk.diskSizeGB	The Azure disk size for the VM.	Integer that represents the size of the disk in GB. The default is **1024**.
controlPlane.platform.azure.osDisk.diskType	Defines the type of disk.	**premium_LRS** or **standardSSD_LRS**. The default is **premium_LRS**.

Parameter	Description	Values
controlPlane.platform.azure.ultraSSDCapability	Enables the use of Azure ultra disks for persistent storage on control plane machines. This requires that your Azure region and zone have ultra disks available.	**Enabled**, **Disabled**. The default is **Disabled**.
controlPlane.platform.azure.vmNetworkingType	Enables accelerated networking. Accelerated networking enables single root I/O virtualization (SR-IOV) to a VM, improving its networking performance. If instance type of control plane machines support **Accelerated** networking, by default, the installer enables **Accelerated** networking, otherwise the default networking type is **Basic**.	**Accelerated** or **Basic**.
platform.azure.baseDomainResourceGroupName	The name of the resource group that contains the DNS zone for your base domain.	String, for example **production_cluster**.
platform.azure.resourceGroupName	The name of an already existing resource group to install your cluster to. This resource group must be empty and only used for this specific cluster; the cluster components assume ownership of all resources in the resource group. If you limit the service principal scope of the installation program to this resource group, you must ensure all other resources used by the installation program in your environment have the necessary permissions, such as the public DNS zone and virtual network. Destroying the cluster by using the installation program deletes this resource group.	String, for example **existing_resource_group**.
platform.azure.outboundType	The outbound routing strategy used to connect your cluster to the internet. If you are using user-defined routing, you must have pre-existing networking available where the outbound routing has already been configured prior to installing a cluster. The installation program is not responsible for configuring user-defined routing.	**LoadBalancer** or **UserDefinedRouting**. The default is **LoadBalancer**.

Parameter	Description	Values
platform.azure.region	The name of the Azure region that hosts your cluster.	Any valid region name, such as **centralus**.
platform.azure.zone	List of availability zones to place machines in. For high availability, specify at least two zones.	List of zones, for example **["1", "2", "3"]**.
platform.azure.defaultMachinePlatform.ultraSSDCapability	Enables the use of Azure ultra disks for persistent storage on control plane and compute machines. This requires that your Azure region and zone have ultra disks available.	**Enabled**, **Disabled**. The default is **Disabled**.
platform.azure.networkResourceGroupName	The name of the resource group that contains the existing VNet that you want to deploy your cluster to. This name cannot be the same as the **platform.azure.baseDomainResourceGroupName**.	String.
platform.azure.virtualNetwork	The name of the existing VNet that you want to deploy your cluster to.	String.
platform.azure.controlPlaneSubnet	The name of the existing subnet in your VNet that you want to deploy your control plane machines to.	Valid CIDR, for example **10.0.0.0/16**.
platform.azure.computeSubnet	The name of the existing subnet in your VNet that you want to deploy your compute machines to.	Valid CIDR, for example **10.0.0.0/16**.
platform.azure.cloudName	The name of the Azure cloud environment that is used to configure the Azure SDK with the appropriate Azure API endpoints. If empty, the default value **AzurePublicCloud** is used.	Any valid cloud environment, such as **AzurePublicCloud** or **AzureUSGovernmentCloud**.
platform.azure.defaultMachinePlatform.vmNetworkingType	Enables accelerated networking. Accelerated networking enables single root I/O virtualization (SR-IOV) to a VM, improving its networking performance.	**Accelerated** or **Basic**. If instance type of control plane and compute machines support **Accelerated** networking, by default, the installer enables **Accelerated** networking, otherwise the default networking type is **Basic**.



NOTE

You cannot customize Azure Availability Zones or Use tags to organize your Azure resources with an Azure cluster.

6.10.8.2. Minimum resource requirements for cluster installation

Each cluster machine must meet the following minimum requirements:

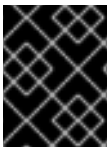
Table 6.35. Minimum resource requirements

Machine	Operating System	vCPU [1]	Virtual RAM	Storage	IOPS [2]
Bootstrap	RHCOS	4	16 GB	100 GB	300
Control plane	RHCOS	4	16 GB	100 GB	300
Compute	RHCOS, RHEL 8.6 and later [3]	2	8 GB	100 GB	300

1. One vCPU is equivalent to one physical core when simultaneous multithreading (SMT), or hyperthreading, is not enabled. When enabled, use the following formula to calculate the corresponding ratio: (threads per core × cores) × sockets = vCPUs.

2. OpenShift Container Platform and Kubernetes are sensitive to disk performance, and faster storage is recommended, particularly for etcd on the control plane nodes which require a 10 ms p99 fsync duration. Note that on many cloud platforms, storage size and IOPS scale together, so you might need to over-allocate storage volume to obtain sufficient performance.

3. As with all user-provisioned installations, if you choose to use RHEL compute machines in your cluster, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks. Use of RHEL 7 compute machines is deprecated and has been removed in OpenShift Container Platform 4.10 and later.



IMPORTANT

You are required to use Azure virtual machines that have the **premiumIO** parameter set to **true**.

If an instance type for your platform meets the minimum requirements for cluster machines, it is supported to use in OpenShift Container Platform.

Additional resources

- Optimizing storage

6.10.8.3. Tested instance types for Azure

The following Microsoft Azure instance types have been tested with OpenShift Container Platform.

-

Example 6.5. Machine types

- **c4.***
- **c5.***
- **c5a.***
- **i3.***
- **m4.***
- **m5.***
- **m5a.***
- **m6a.***
- **m6i.***
- **r4.***
- **r5.***
- **r5a.***
- **r6i.***
- **t3.***
- **t3a.***

6.10.8.4. Sample customized install-config.yaml file for Azure

You can customize the **install-config.yaml** file to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.

IMPORTANT

This sample YAML file is provided for reference only. You must obtain your **install-config.yaml** file by using the installation program and modify it.

```
apiVersion: v1
baseDomain: example.com (1)
controlPlane: (2)
  hyperthreading: Enabled (3) (4)
  name: master
  platform:
    azure:
      encryptionAtHost: true
      ultraSSDCapability: Enabled
      osDisk:
        diskSizeGB: 1024 (5)
        diskType: Premium_LRS
```

```
        diskEncryptionSet:
          resourceGroup: disk_encryption_set_resource_group
          name: disk_encryption_set_name
          subscriptionId: secondary_subscription_id
      type: Standard_D8s_v3
  replicas: 3
compute: 6
- hyperthreading: Enabled 7
  name: worker
  platform:
    azure:
      ultraSSDCapability: Enabled
      type: Standard_D2s_v3
      encryptionAtHost: true
      osDisk:
        diskSizeGB: 512 8
        diskType: Standard_LRS
        diskEncryptionSet:
          resourceGroup: disk_encryption_set_resource_group
          name: disk_encryption_set_name
          subscriptionId: secondary_subscription_id
      zones: 9
      - "1"
      - "2"
      - "3"
  replicas: 5
metadata:
  name: test-cluster 10
networking:
  clusterNetwork:
  - cidr: 10.128.0.0/14
    hostPrefix: 23
  machineNetwork:
  - cidr: 10.0.0.0/16
  networkType: OpenShiftSDN
  serviceNetwork:
  - 172.30.0.0/16
platform:
  azure:
    defaultMachinePlatform:
      ultraSSDCapability: Enabled
    baseDomainResourceGroupName: resource_group 11
    region: usgovvirginia
    resourceGroupName: existing_resource_group 12
    networkResourceGroupName: vnet_resource_group 13
    virtualNetwork: vnet 14
    controlPlaneSubnet: control_plane_subnet 15
    computeSubnet: compute_subnet 16
    outboundType: UserDefinedRouting 17
    cloudName: AzureUSGovernmentCloud 18
pullSecret: '{"auths": ...}' 19
fips: false 20
sshKey: ssh-ed25519 AAAA... 21
publish: Internal 22
```

-

1 10 19 Required.

2 6 If you do not provide these parameters and values, the installation program provides the default value.

3 7 The **controlPlane** section is a single mapping, but the **compute** section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, **-**, and the first line of the **controlPlane** section must not. Only one control plane pool is used.

4 Whether to enable or disable simultaneous multithreading, or **hyperthreading**. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores. You can disable it by setting the parameter value to **Disabled**. If you disable simultaneous multithreading in some cluster machines, you must disable it in all cluster machines.

IMPORTANT

If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance. Use larger virtual machine types, such as **Standard_D8s_v3**, for your machines if you disable simultaneous multithreading.

5 8 You can specify the size of the disk to use in GB. Minimum recommendation for control plane nodes is 1024 GB.

9 Specify a list of zones to deploy your machines to. For high availability, specify at least two zones.

11 Specify the name of the resource group that contains the DNS zone for your base domain.

12 Specify the name of an already existing resource group to install your cluster to. If undefined, a new resource group is created for the cluster.

13 If you use an existing VNet, specify the name of the resource group that contains it.

14 If you use an existing VNet, specify its name.

15 If you use an existing VNet, specify the name of the subnet to host the control plane machines.

16 If you use an existing VNet, specify the name of the subnet to host the compute machines.

17 You can customize your own outbound routing. Configuring user-defined routing prevents exposing external endpoints in your cluster. User-defined routing for egress requires deploying your cluster to an existing VNet.

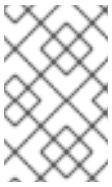
18 Specify the name of the Azure cloud environment to deploy your cluster to. Set **AzureUSGovernmentCloud** to deploy to a Microsoft Azure Government (MAG) region. The default value is **AzurePublicCloud**.

20 Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.

IMPORTANT

To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.

21 You can optionally provide the **sshKey** value that you use to access the machines in your cluster.



NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

22 How to publish the user-facing endpoints of your cluster. Set **publish** to **Internal** to deploy a private cluster, which cannot be accessed from the internet. The default value is **External**.

6.10.8.5. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.

NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

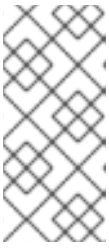
```
apiVersion: v1
baseDomain: my.domain.com
proxy:
```

```
httpProxy: http://<username>:<pswd>@<ip>:<port> 1
httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
noProxy: example.com 3
additionalTrustBundle: | 4
  -----BEGIN CERTIFICATE-----
  <MY_TRUSTED_CA_CERT>
  -----END CERTIFICATE-----
```

1. A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
2. A proxy URL to use for creating HTTPS connections outside the cluster.
3. A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use ***** to bypass the proxy for all destinations.
4. If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace that contains one or more additional CA certificates that are required for proxying HTTPS connections. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges these contents with the Red Hat Enterprise Linux CoreOS (RHCOS) trust bundle, and this config map is referenced in the **trustedCA** field of the **Proxy** object. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.

NOTE

The installation program does not support the proxy **readinessEndpoints** field.



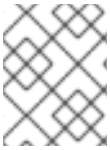
NOTE

If the installer times out, restart and then complete the deployment by using the **wait-for** command of the installer. For example:

```
$ ./openshift-install wait-for install-complete --log-level debug
```

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.



NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

Additional resources

- For more details about Accelerated Networking, see Accelerated Networking for Microsoft Azure VMs.

6.10.9. Deploying the cluster

You can install OpenShift Container Platform on a compatible cloud platform.

IMPORTANT

You can run the **create cluster** command of the installation program only once, during initial installation.

Prerequisites

- Configure an account with the cloud platform that hosts your cluster.
- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.

Procedure

- Change to the directory that contains the installation program and initialize the cluster deployment:

```
$ ./openshift-install create cluster --dir <installation_directory> \ 1
    --log-level=info 2
```

1 For **<installation_directory>**, specify the location of your customized **./install-config.yaml** file.

2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

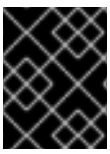
NOTE

If the cloud provider account that you configured on your host does not have sufficient permissions to deploy the cluster, the installation process stops, and the missing permissions are displayed.

Verification

When the cluster deployment completes successfully:

- The terminal displays directions for accessing your cluster, including a link to the web console and credentials for the **kubeadmin** user.
- Credential information also outputs to **<installation_directory>/.openshift_install.log**.



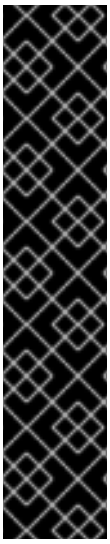
IMPORTANT

Do not delete the installation program or the files that the installation program creates. Both are required to delete the cluster.

Example output

```
...
INFO Install complete!
```

```
INFO To access the cluster as the system:admin user when using 'oc', run 'export
KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
INFO Access the OpenShift web-console here: https://console-openshift-
console.apps.mycluster.example.com
INFO Login to the console with user: "kubeadmin", and password: "password"
INFO Time elapsed: 36m22s
```



IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

6.10.10. Finalizing user-managed encryption after installation

If you installed OpenShift Container Platform using a user-managed encryption key, you can complete the installation by creating a new storage class and granting write permissions to the Azure cluster resource group.

Procedure

1. Obtain the identity of the cluster resource group used by the installer:
   a. If you specified an existing resource group in **install-config.yaml**, obtain its Azure identity by running the following command:

      ```
      $ az identity list --resource-group "<existing_resource_group>"
      ```

   b. If you did not specify a existing resource group in **install-config.yaml**, locate the resource group that the installer created, and then obtain its Azure identity by running the following commands:

      ```
      $ az group list
      ```

      ```
      $ az identity list --resource-group "<installer_created_resource_group>"
      ```

2. Grant a role assignment to the cluster resource group so that it can write to the Disk Encryption Set by running the following command:

   ```
   $ az role assignment create --role "<privileged_role>" \ 1
     --assignee "<resource_group_identity>" 2
   ```

1. Specifies an Azure role that has read/write permissions to the disk encryption set. You can use the **Owner** role or a custom role with the necessary permissions.
2. Specifies the identity of the cluster resource group.

3. Obtain the **id** of the disk encryption set you created prior to installation by running the following command:

```
$ az disk-encryption-set show -n <disk_encryption_set_name> \ 1
   --resource-group <resource_group_name> 2
```

1. Specifies the name of the disk encryption set.
2. Specifies the resource group that contains the disk encryption set. The **id** is in the format of **"/subscriptions/.../resourceGroups/... /providers/Microsoft.Compute/diskEncryptionSets/..."**.

4. Obtain the identity of the cluster service principal by running the following command:

```
$ az identity show -g <cluster_resource_group> \ 1
   -n <cluster_service_principal_name> \ 2
   --query principalId --out tsv
```

1. Specifies the name of the cluster resource group created by the installation program.
2. Specifies the name of the cluster service principal created by the installation program. The identity is in the format of **12345678-1234-1234-1234-1234567890**.

5. Create a role assignment that grants the cluster service principal **Contributor** privileges to the disk encryption set by running the following command:

```
$ az role assignment create --assignee <cluster_service_principal_id> \ 1
   --role 'Contributor' \//
   --scope <disk_encryption_set_id> \ 2
```

1. Specifies the ID of the cluster service principal obtained in the previous step.
2. Specifies the ID of the disk encryption set.

6. Create a storage class that uses the user-managed disk encryption set:

   a. Save the following storage class definition to a file, for example **storage-class-definition.yaml**:

```
kind: StorageClass
apiVersion: storage.k8s.io/v1
metadata:
  name: managed-premium
provisioner: kubernetes.io/azure-disk
parameters:
  skuname: Premium_LRS
```

```
    kind: Managed
    diskEncryptionSetID: "<disk_encryption_set_ID>" (1)
    resourceGroup: "<resource_group_name>" (2)
reclaimPolicy: Delete
allowVolumeExpansion: true
volumeBindingMode: WaitForFirstConsumer
```

(1) Specifies the ID of the disk encryption set that you created in the prerequisite steps, for example **"/subscriptions/xxxxxx-xxxxx-xxxxx/resourceGroups/test-encryption/providers/Microsoft.Compute/diskEncryptionSets/disk-encryption-set-xxxxxx"**.

(2) Specifies the name of the resource group used by the installer. This is the same resource group from the first step.

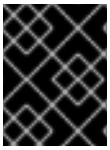
b. Create the storage class **managed-premium** from the file you created by running the following command:

```
$ oc create -f storage-class-definition.yaml
```

7. Select the **managed-premium** storage class when you create persistent volumes to use encrypted storage.

6.10.11. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.



IMPORTANT

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.11. Download and install the new version of **oc**.

Installing the OpenShift CLI on Linux

You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the architecture in the **Product Variant** drop-down menu.
3. Select the appropriate version in the **Version** drop-down menu.
4. Click **Download Now** next to the **OpenShift v4.11 Linux Client** entry and save the file.
5. Unpack the archive:

```
$ tar xvf <file>
```

6. Place the **oc** binary in a directory that is on your **PATH**.
   To check your **PATH**, execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

Installing the OpenShift CLI on Windows
You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.
   To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

Verification

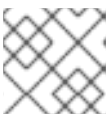
- After you install the OpenShift CLI, it is available using the **oc** command:

```
C:\> oc <command>
```

Installing the OpenShift CLI on macOS
You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 macOS Client** entry and save the file.



NOTE

For macOS arm64, choose the **OpenShift v4.11 macOS arm64 Client** entry.

4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your PATH.
   To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

6.10.12. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

Example output

```
system:admin
```

Additional resources

- See Accessing the web console for more details about accessing and understanding the OpenShift Container Platform web console.

6.10.13. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.11, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to OpenShift Cluster Manager Hybrid Cloud Console.

After you confirm that your OpenShift Cluster Manager Hybrid Cloud Console inventory is correct,

either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, use subscription watch to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

Additional resources

- See About remote health monitoring for more information about the Telemetry service

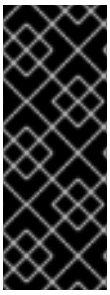
6.10.14. Next steps

- Customize your cluster.
- If necessary, you can opt out of remote health reporting .

6.11. INSTALLING A CLUSTER ON AZURE USING ARM TEMPLATES

In OpenShift Container Platform version 4.11, you can install a cluster on Microsoft Azure by using infrastructure that you provide.

Several Azure Resource Manager (ARM) templates are provided to assist in completing these steps or to help model your own.



IMPORTANT

The steps for performing a user-provisioned infrastructure installation are provided as an example only. Installing a cluster with infrastructure you provide requires knowledge of the cloud provider and the installation process of OpenShift Container Platform. Several ARM templates are provided to assist in completing these steps or to help model your own. You are also free to create the required resources through other methods; the templates are just an example.

6.11.1. Prerequisites

- You reviewed details about the OpenShift Container Platform installation and update processes.
- You read the documentation on selecting a cluster installation method and preparing it for users.
- You configured an Azure account to host the cluster.
- You downloaded the Azure CLI and installed it on your computer. See Install the Azure CLI in the Azure documentation. The documentation below was last tested using version **2.38.0** of the Azure CLI. Azure CLI commands might perform differently based on the version you use.
- If you use a firewall and plan to use the Telemetry service, you configured the firewall to allow the sites that your cluster requires access to.
- If the cloud identity and access management (IAM) APIs are not accessible in your environment, or if you do not want to store an administrator-level credential secret in the **kube-system** namespace, you can manually create and maintain IAM credentials.

NOTE

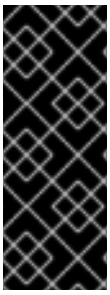
Be sure to also review this site list if you are configuring a proxy.

6.11.2. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.11, you require access to the internet to install your cluster.

You must have internet access to:

- Access OpenShift Cluster Manager Hybrid Cloud Console to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access Quay.io to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.



IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

6.11.3. Configuring your Azure project

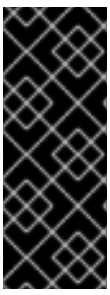
Before you can install OpenShift Container Platform, you must configure an Azure project to host it.

IMPORTANT

All Azure resources that are available through public endpoints are subject to resource name restrictions, and you cannot create resources that use certain terms. For a list of terms that Azure restricts, see Resolve reserved resource name errors in the Azure documentation.

6.11.3.1. Azure account limits

The OpenShift Container Platform cluster uses a number of Microsoft Azure components, and the default Azure subscription and service limits, quotas, and constraints affect your ability to install OpenShift Container Platform clusters.



IMPORTANT

Default limits vary by offer category types, such as Free Trial and Pay-As-You-Go, and by series, such as Dv2, F, and G. For example, the default for Enterprise Agreement subscriptions is 350 cores.

Check the limits for your subscription type and if necessary, increase quota limits for your account before you install a default cluster on Azure.

The following table summarizes the Azure components whose limits can impact your ability to install and run OpenShift Container Platform clusters.

Component	Number of components required by default	Default Azure limit	Description
vCPU	40	20 per region	A default cluster requires 40 vCPUs, so you must increase the account limit. By default, each cluster creates the following instances: • One bootstrap machine, which is removed after installation • Three control plane machines • Three compute machines Because the bootstrap machine uses **Standard_D4s_v3** machines, which use 4 vCPUs, the control plane machines use **Standard_D8s_v3** virtual machines, which use 8 vCPUs, and the worker machines use **Standard_D4s_v3** virtual machines, which use 4 vCPUs, a default cluster requires 40 vCPUs. The bootstrap node VM, which uses 4 vCPUs, is used only during installation. To deploy more worker nodes, enable autoscaling, deploy large workloads, or use a different instance type, you must further increase the vCPU limit for your account to ensure that your cluster can deploy the machines that you require.
OS Disk	7		Each cluster machine must have a minimum of 100 GB of storage and 300 IOPS. While these are the minimum supported values, faster storage is recommended for production clusters and clusters with intensive workloads. For more information about optimizing storage for performance, see the page titled "Optimizing storage" in the "Scalability and performance" section.
VNet	1	1000 per region	Each default cluster requires one Virtual Network (VNet), which contains two subnets.
Network interfaces	7	65,536 per region	Each default cluster requires seven network interfaces. If you create more machines or your deployed workloads create load balancers, your cluster uses more network interfaces.

Component	Number of components required by default	Default Azure limit	Description
Network security groups	2	5000	Each cluster creates network security groups for each subnet in the VNet. The default cluster creates network security groups for the control plane and for the compute node subnets: **controlplane** — Allows the control plane machines to be reached on port 6443 from anywhere **node** — Allows worker nodes to be reached from the internet on ports 80 and 443
Network load balancers	3	1000 per region	Each cluster creates the following load balancers: **default** — Public IP address that load balances requests to ports 80 and 443 across worker machines **internal** — Private IP address that load balances requests to ports 6443 and 22623 across control plane machines **external** — Public IP address that load balances requests to port 6443 across control plane machines If your applications create more Kubernetes **LoadBalancer** service objects, your cluster uses more load balancers.
Public IP addresses	3		Each of the two public load balancers uses a public IP address. The bootstrap machine also uses a public IP address so that you can SSH into the machine to troubleshoot issues during installation. The IP address for the bootstrap node is used only during installation.
Private IP addresses	7		The internal load balancer, each of the three control plane machines, and each of the three worker machines each use a private IP address.

Component	Number of components required by default	Default Azure limit	Description
Spot VM vCPUs (optional)	0 If you configure spot VMs, your cluster must have two spot VM vCPUs for every compute node.	20 per region	This is an optional component. To use spot VMs, you must increase the Azure default limit to at least twice the number of compute nodes in your cluster.  **NOTE** Using spot VMs for control plane nodes is not recommended.

Additional resources

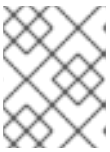
- Optimizing storage.

6.11.3.2. Configuring a public DNS zone in Azure

To install OpenShift Container Platform, the Microsoft Azure account you use must have a dedicated public hosted DNS zone in your account. This zone must be authoritative for the domain. This service provides cluster DNS resolution and name lookup for external connections to the cluster.

Procedure

1. Identify your domain, or subdomain, and registrar. You can transfer an existing domain and registrar or obtain a new one through Azure or another source.

   NOTE

   For more information about purchasing domains through Azure, see Buy a custom domain name for Azure App Service in the Azure documentation.

2. If you are using an existing domain and registrar, migrate its DNS to Azure. See Migrate an active DNS name to Azure App Service in the Azure documentation.

3. Configure DNS for your domain. Follow the steps in the Tutorial: Host your domain in Azure DNS in the Azure documentation to create a public hosted zone for your domain or subdomain, extract the new authoritative name servers, and update the registrar records for the name servers that your domain uses.
   Use an appropriate root domain, such as **openshiftcorp.com**, or subdomain, such as **clusters.openshiftcorp.com**.

4. If you use a subdomain, follow your company's procedures to add its delegation records to the parent domain.

You can view Azure's DNS solution by visiting this example for creating DNS zones.

6.11.3.3. Increasing Azure account limits

To increase an account limit, file a support request on the Azure portal.

NOTE

You can increase only one type of quota per support request.

Procedure

1. From the Azure portal, click **Help + support** in the lower left corner.
2. Click **New support request** and then select the required values:
    a. From the **Issue type** list, select **Service and subscription limits (quotas)**
    b. From the **Subscription** list, select the subscription to modify.
    c. From the **Quota type** list, select the quota to increase. For example, select **Compute-VM (cores-vCPUs) subscription limit increases** to increase the number of vCPUs, which is required to install a cluster.
    d. Click **Next: Solutions**.
3. On the **Problem Details** page, provide the required information for your quota increase:
    a. Click **Provide details** and provide the required details in the **Quota details** window.
    b. In the SUPPORT METHOD and CONTACT INFO sections, provide the issue severity and your contact details.
4. Click **Next: Review + create** and then click **Create**.

6.11.3.4. Certificate signing requests management

Because your cluster has limited access to automatic machine management when you use infrastructure that you provision, you must provide a mechanism for approving cluster certificate signing requests (CSRs) after installation. The **kube-controller-manager** only approves the kubelet client CSRs. The **machine-approver** cannot guarantee the validity of a serving certificate that is requested by using kubelet credentials because it cannot confirm that the correct machine issued the request. You must determine and implement a method of verifying the validity of the kubelet serving certificate requests and approving them.

6.11.3.5. Required Azure roles

OpenShift Container Platform needs a service principal so it can manage Microsoft Azure resources. Before you can create a service principal, review the following information:

Your Azure account subscription must have the following roles:

- **User Access Administrator**
- **Contributor**

Your Azure Active Directory (AD) must have the following permission:

- **"microsoft.directory/servicePrincipals/createAsOwner"**

To set roles on the Azure portal, see the Manage access to Azure resources using RBAC and the Azure portal in the Azure documentation.

6.11.3.6. Creating a service principal

Because OpenShift Container Platform and its installation program create Microsoft Azure resources by using the Azure Resource Manager, you must create a service principal to represent it.

Prerequisites

- Install or update the Azure CLI.
- Your Azure account has the required roles for the subscription that you use.

Procedure

1. Log in to the Azure CLI:

```
$ az login
```

2. If your Azure account uses subscriptions, ensure that you are using the right subscription:

   a. View the list of available accounts and record the **tenantId** value for the subscription you want to use for your cluster:

```
$ az account list --refresh
```

   Example output

```
[
  {
    "cloudName": "AzureCloud",
    "id": "9bab1460-96d5-40b3-a78e-17b15e978a80",
    "isDefault": true,
    "name": "Subscription Name",
    "state": "Enabled",
    "tenantId": "6057c7e9-b3ae-489d-a54e-de3f6bf6a8ee",
    "user": {
      "name": "you@example.com",
      "type": "user"
    }
  }
]
```

   b. View your active account details and confirm that the **tenantId** value matches the subscription you want to use:

```
$ az account show
```

   Example output

```
{
  "environmentName": "AzureCloud",
  "id": "9bab1460-96d5-40b3-a78e-17b15e978a80",
  "isDefault": true,
  "name": "Subscription Name",
  "state": "Enabled",
```

```
  "tenantId": "6057c7e9-b3ae-489d-a54e-de3f6bf6a8ee", (1)
  "user": {
    "name": "you@example.com",
    "type": "user"
  }
}
```

(1) Ensure that the value of the **tenantId** parameter is the correct subscription ID.

c. If you are not using the right subscription, change the active subscription:

```
$ az account set -s <subscription_id> (1)
```

(1) Specify the subscription ID.

d. Verify the subscription ID update:

```
$ az account show
```

Example output

```
{
  "environmentName": "AzureCloud",
  "id": "33212d16-bdf6-45cb-b038-f6565b61edda",
  "isDefault": true,
  "name": "Subscription Name",
  "state": "Enabled",
  "tenantId": "8049c7e9-c3de-762d-a54e-dc3f6be6a7ee",
  "user": {
    "name": "you@example.com",
    "type": "user"
  }
}
```

3. Record the **tenantId** and **id** parameter values from the output. You need these values during the OpenShift Container Platform installation.

4. Create the service principal for your account:

```
$ az ad sp create-for-rbac --role Contributor --name <service_principal> \ (1)
  --scopes /subscriptions/<subscription_id> (2)
  --years <years> (3)
```

(1) Specify the service principal name.

(2) Specify the subscription ID.

(3) Specify the number of years. By default, a service principal expires in one year. By using the **--years** option you can extend the validity of your service principal.

Example output

```
Creating 'Contributor' role assignment under scope '/subscriptions/<subscription_id>'
The output includes credentials that you must protect. Be sure that you do not
include these credentials in your code or check the credentials into your source
control. For more information, see https://aka.ms/azadsp-cli
{
  "appId": "ac461d78-bf4b-4387-ad16-7e32e328aec6",
  "displayName": <service_principal>",
  "password": "00000000-0000-0000-0000-000000000000",
  "tenantId": "8049c7e9-c3de-762d-a54e-dc3f6be6a7ee"
}
```

5. Record the values of the **appId** and **password** parameters from the previous output. You need these values during OpenShift Container Platform installation.

6. Assign the **User Access Administrator** role by running the following command:

```
$ az role assignment create --role "User Access Administrator" \
  --assignee-object-id $(az ad sp show --id <appId> --query id -o tsv) 1
```

1 Specify the **appId** parameter value for your service principal.

Additional resources

- For more information about CCO modes, see About the Cloud Credential Operator.

6.11.3.7. Supported Azure regions

The installation program dynamically generates the list of available Microsoft Azure regions based on your subscription.

Supported Azure public regions

- **australiacentral** (Australia Central)
- **australiaeast** (Australia East)
- **australiasoutheast** (Australia South East)
- **brazilsouth** (Brazil South)
- **canadacentral** (Canada Central)
- **canadaeast** (Canada East)
- **centralindia** (Central India)
- **centralus** (Central US)
- **eastasia** (East Asia)
- **eastus** (East US)
- **eastus2** (East US 2)
- **francecentral** (France Central)

- **germanywestcentral** (Germany West Central)
- **israelcentral** (Israel Central)
- **italynorth** (Italy North)
- **japaneast** (Japan East)
- **japanwest** (Japan West)
- **koreacentral** (Korea Central)
- **koreasouth** (Korea South)
- **northcentralus** (North Central US)
- **northeurope** (North Europe)
- **norwayeast** (Norway East)
- **polandcentral** (Poland Central)
- **qatarcentral** (Qatar Central)
- **southafricanorth** (South Africa North)
- **southcentralus** (South Central US)
- **southeastasia** (Southeast Asia)
- **southindia** (South India)
- **swedencentral** (Sweden Central)
- **switzerlandnorth** (Switzerland North)
- **uaenorth** (UAE North)
- **uksouth** (UK South)
- **ukwest** (UK West)
- **westcentralus** (West Central US)
- **westeurope** (West Europe)
- **westindia** (West India)
- **westus** (West US)
- **westus2** (West US 2)
- **westus3** (West US 3)

Supported Azure Government regions
Support for the following Microsoft Azure Government (MAG) regions was added in OpenShift Container Platform version 4.6:

- **usgovtexas** (US Gov Texas)
- **usgovvirginia** (US Gov Virginia)

You can reference all available MAG regions in the Azure documentation. Other provided MAG regions are expected to work with OpenShift Container Platform, but have not been tested.

6.11.4. Requirements for a cluster with user-provisioned infrastructure

For a cluster that contains user-provisioned infrastructure, you must deploy all of the required machines.

This section describes the requirements for deploying OpenShift Container Platform on user-provisioned infrastructure.

6.11.4.1. Required machines for cluster installation

The smallest OpenShift Container Platform clusters require the following hosts:

Table 6.36. Minimum required hosts

Hosts	Description
One temporary bootstrap machine	The cluster requires the bootstrap machine to deploy the OpenShift Container Platform cluster on the three control plane machines. You can remove the bootstrap machine after you install the cluster.
Three control plane machines	The control plane machines run the Kubernetes and OpenShift Container Platform services that form the control plane.
At least two compute machines, which are also known as worker machines.	The workloads requested by OpenShift Container Platform users run on the compute machines.

IMPORTANT

To maintain high availability of your cluster, use separate physical hosts for these cluster machines.

The bootstrap and control plane machines must use Red Hat Enterprise Linux CoreOS (RHCOS) as the operating system. However, the compute machines can choose between Red Hat Enterprise Linux CoreOS (RHCOS), Red Hat Enterprise Linux (RHEL) 8.6 and later.

Note that RHCOS is based on Red Hat Enterprise Linux (RHEL) 8 and inherits all of its hardware certifications and requirements. See Red Hat Enterprise Linux technology capabilities and limits .

6.11.4.2. Minimum resource requirements for cluster installation

Each cluster machine must meet the following minimum requirements:

Table 6.37. Minimum resource requirements

Machine	Operating System	vCPU [1]	Virtual RAM	Storage	IOPS [2]
Bootstrap	RHCOS	4	16 GB	100 GB	300
Control plane	RHCOS	4	16 GB	100 GB	300
Compute	RHCOS, RHEL 8.6 and later [3]	2	8 GB	100 GB	300

1. One vCPU is equivalent to one physical core when simultaneous multithreading (SMT), or hyperthreading, is not enabled. When enabled, use the following formula to calculate the corresponding ratio: (threads per core × cores) × sockets = vCPUs.
2. OpenShift Container Platform and Kubernetes are sensitive to disk performance, and faster storage is recommended, particularly for etcd on the control plane nodes which require a 10 ms p99 fsync duration. Note that on many cloud platforms, storage size and IOPS scale together, so you might need to over-allocate storage volume to obtain sufficient performance.
3. As with all user-provisioned installations, if you choose to use RHEL compute machines in your cluster, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks. Use of RHEL 7 compute machines is deprecated and has been removed in OpenShift Container Platform 4.10 and later.

IMPORTANT

You are required to use Azure virtual machines that have the **premiumIO** parameter set to **true**.

If an instance type for your platform meets the minimum requirements for cluster machines, it is supported to use in OpenShift Container Platform.

Additional resources

- Optimizing storage

6.11.4.3. Tested instance types for Azure

The following Microsoft Azure instance types have been tested with OpenShift Container Platform.

Example 6.6. Machine types

- **c4.***
- **c5.***
- **c5a.***
- **i3.***

- **m4.***
- **m5.***
- **m5a.***
- **m6a.***
- **m6i.***
- **r4.***
- **r5.***
- **r5a.***
- **r6i.***
- **t3.***
- **t3a.***

6.11.5. Selecting an Azure Marketplace image

If you are deploying an OpenShift Container Platform cluster using the Azure Marketplace offering, you must first obtain the Azure Marketplace image. The installation program uses this image to deploy worker nodes. When obtaining your image, consider the following:

- While the images are the same, the Azure Marketplace publisher is different depending on your region. If you are located in North America, specify **redhat** as the publisher. If you are located in EMEA, specify **redhat-limited** as the publisher.
- The offer includes a **rh-ocp-worker** SKU and a **rh-ocp-worker-gen1** SKU. The **rh-ocp-worker** SKU represents a Hyper-V generation version 2 VM image. The default instance types used in OpenShift Container Platform are version 2 compatible. If you are going to use an instance type that is only version 1 compatible, use the image associated with the **rh-ocp-worker-gen1** SKU. The **rh-ocp-worker-gen1** SKU represents a Hyper-V version 1 VM image.

Prerequisites

- You have installed the Azure CLI client **(az)**.
- Your Azure account is entitled for the offer and you have logged into this account with the Azure CLI client.

Procedure

1. Display all of the available OpenShift Container Platform images by running one of the following commands:
   - North America:

     ```
     $ az vm image list --all --offer rh-ocp-worker --publisher redhat -o table
     ```

     Example output

```
Offer          Publisher       Sku                 Urn                                                                  Version
-------------  --------------  ------------------  -------------------------------------------------------------------
----  --------------
rh-ocp-worker  RedHat          rh-ocp-worker       RedHat:rh-ocp-worker:rh-
ocpworker:4.8.2021122100               4.8.2021122100
rh-ocp-worker  RedHat          rh-ocp-worker-gen1  RedHat:rh-ocp-worker:rh-ocp-worker-
gen1:4.8.2021122100         4.8.2021122100
```

- EMEA:

```
$  az vm image list --all --offer rh-ocp-worker --publisher redhat-limited -o table
```

Example output

```
Offer          Publisher       Sku                 Urn                                                                  Version
-------------  --------------  ------------------  -------------------------------------------------------------------
----  --------------
rh-ocp-worker  redhat-limited  rh-ocp-worker       redhat-limited:rh-ocp-worker:rh-ocp-
worker:4.8.2021122100       4.8.2021122100
rh-ocp-worker  redhat-limited  rh-ocp-worker-gen1  redhat-limited:rh-ocp-worker:rh-ocp-
worker-gen1:4.8.2021122100  4.8.2021122100
```

NOTE

Regardless of the version of OpenShift Container Platform you are installing, the correct version of the Azure Marketplace image to use is 4.8.x. If required, as part of the installation process, your VMs are automatically upgraded.

2. Inspect the image for your offer by running one of the following commands:
   - North America:

```
$ az vm image show --urn redhat:rh-ocp-worker:rh-ocp-worker:<version>
```

   - EMEA:

```
$ az vm image show --urn redhat-limited:rh-ocp-worker:rh-ocp-worker:<version>
```

3. Review the terms of the offer by running one of the following commands:
   - North America:

```
$ az vm image terms show --urn redhat:rh-ocp-worker:rh-ocp-worker:<version>
```

   - EMEA:

```
$ az vm image terms show --urn redhat-limited:rh-ocp-worker:rh-ocp-worker:<version>
```

4. Accept the terms of the offering by running one of the following commands:
   - North America:

```
$ az vm image terms accept --urn redhat:rh-ocp-worker:rh-ocp-worker:<version>
```

- EMEA:

```
$ az vm image terms accept --urn redhat-limited:rh-ocp-worker:rh-ocp-worker:<version>
```

5. Record the image details of your offer. If you use the Azure Resource Manager (ARM) template to deploy your worker nodes:

   a. Update **storageProfile.imageReference** by deleting the **id** parameter and adding the **offer**, **publisher**, **sku**, and **version** parameters by using the values from your offer.

   b. Specify a **plan** for the virtual machines (VMs).

   Example 06_workers.json ARM template with an updated storageProfile.imageReference object and a specified plan

```
...
  "plan" : {
    "name": "rh-ocp-worker",
    "product": "rh-ocp-worker",
    "publisher": "redhat"
  },
  "dependsOn" : [
    "[concat('Microsoft.Network/networkInterfaces/', concat(variables('vmNames')
[copyIndex()], '-nic'))]"
  ],
  "properties" : {
...
  "storageProfile": {
    "imageReference": {
    "offer": "rh-ocp-worker",
    "publisher": "redhat",
    "sku": "rh-ocp-worker",
    "version": "4.8.2021122100"
    }
    ...
  }
...
  }
```

6.11.6. Obtaining the installation program

Before you install OpenShift Container Platform, download the installation file on a local computer.

Prerequisites

- You have a computer that runs Linux or macOS, with 500 MB of local disk space.

Procedure

1. Access the Infrastructure Provider page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.

2. Select your infrastructure provider.

3. Navigate to the page for your installation type, download the installation program that corresponds with your host operating system and architecture, and place the file in the directory where you will store the installation configuration files.

IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.

IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation pull secret from the Red Hat OpenShift Cluster Manager . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

6.11.7. Generating a key pair for cluster node SSH access

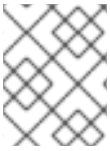
During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the **~/.ssh/authorized_keys** list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The **./openshift-install gather** command also requires the SSH public key to be in place on the cluster nodes.

IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.



NOTE

You must use a local key, not one that you configured with platform-specific approaches such as AWS key pairs.

Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N '' -f <path>/<file_name> 1
```

1 Specify the path and file name, such as ~/**.ssh/id_ed25519**, of the new SSH key. If you have an existing key pair, ensure your public key is in the your ~/**.ssh** directory.

NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS validated or Modules In Process cryptographic libraries on the **x86_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the ~/**.ssh/id_ed25519.pub** public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the **./openshift-install gather** command.

NOTE

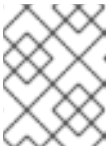
On some distributions, default SSH private key identities such as ~/**.ssh/id_rsa** and ~/**.ssh/id_dsa** are managed automatically.

a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

Example output

```
Agent pid 31874
```



NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

1 Specify the path and file name for your SSH private key, such as **~/.ssh/id_ed25519**

Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program. If you install a cluster on infrastructure that you provision, you must provide the key to the installation program.

6.11.8. Creating the installation files for Azure

To install OpenShift Container Platform on Microsoft Azure using user-provisioned infrastructure, you must generate the files that the installation program needs to deploy your cluster and modify them so that the cluster creates only the machines that it will use. You generate and customize the **install-config.yaml** file, Kubernetes manifests, and Ignition config files. You also have the option to first set up a separate **var** partition during the preparation phases of installation.

6.11.8.1. Optional: Creating a separate /var partition

It is recommended that disk partitioning for OpenShift Container Platform be left to the installer. However, there are cases where you might want to create separate partitions in a part of the filesystem that you expect to grow.

OpenShift Container Platform supports the addition of a single partition to attach storage to either the **/var** partition or a subdirectory of **/var**. For example:

- **/var/lib/containers**: Holds container-related content that can grow as more images and containers are added to a system.
- **/var/lib/etcd**: Holds data that you might want to keep separate for purposes such as performance optimization of etcd storage.
- **/var**: Holds data that you might want to keep separate for purposes such as auditing.

Storing the contents of a **/var** directory separately makes it easier to grow storage for those areas as needed and reinstall OpenShift Container Platform at a later date and keep that data intact. With this method, you will not have to pull all your containers again, nor will you have to copy massive log files when you update systems.

Because **/var** must be in place before a fresh installation of Red Hat Enterprise Linux CoreOS (RHCOS), the following procedure sets up the separate **/var** partition by creating a machine config manifest that is

inserted during the **openshift-install** preparation phases of an OpenShift Container Platform installation.

IMPORTANT

If you follow the steps to create a separate **/var** partition in this procedure, it is not necessary to create the Kubernetes manifest and Ignition config files again as described later in this section.

Procedure

1. Create a directory to hold the OpenShift Container Platform installation files:

```
$ mkdir $HOME/clusterconfig
```

2. Run **openshift-install** to create a set of files in the **manifest** and **openshift** subdirectories. Answer the system questions as you are prompted:

```
$ openshift-install create manifests --dir $HOME/clusterconfig
```

Example output

```
? SSH Public Key ...
INFO Credentials loaded from the "myprofile" profile in file "/home/myuser/.aws/credentials"
INFO Consuming Install Config from target directory
INFO Manifests created in: $HOME/clusterconfig/manifests and
$HOME/clusterconfig/openshift
```

3. Optional: Confirm that the installation program created manifests in the **clusterconfig/openshift** directory:

```
$ ls $HOME/clusterconfig/openshift/
```

Example output

```
99_kubeadmin-password-secret.yaml
99_openshift-cluster-api_master-machines-0.yaml
99_openshift-cluster-api_master-machines-1.yaml
99_openshift-cluster-api_master-machines-2.yaml
...
```

4. Create a Butane config that configures the additional partition. For example, name the file **$HOME/clusterconfig/98-var-partition.bu**, change the disk device name to the name of the storage device on the **worker** systems, and set the storage size as appropriate. This example places the **/var** directory on a separate partition:

```
variant: openshift
version: 4.11.0
metadata:
  labels:
    machineconfiguration.openshift.io/role: worker
  name: 98-var-partition
storage:
```

```
disks:
- device: /dev/<device_name> 1
  partitions:
  - label: var
    start_mib: <partition_start_offset> 2
    size_mib: <partition_size> 3
filesystems:
  - device: /dev/disk/by-partlabel/var
    path: /var
    format: xfs
    mount_options: [defaults, prjquota] 4
    with_mount_unit: true
```

1. The storage device name of the disk that you want to partition.
2. When adding a data partition to the boot disk, a minimum value of 25000 MiB (Mebibytes) is recommended. The root file system is automatically resized to fill all available space up to the specified offset. If no value is specified, or if the specified value is smaller than the recommended minimum, the resulting root file system will be too small, and future reinstalls of RHCOS might overwrite the beginning of the data partition.
3. The size of the data partition in mebibytes.
4. The **prjquota** mount option must be enabled for filesystems used for container storage.

NOTE

When creating a separate **/var** partition, you cannot use different instance types for worker nodes, if the different instance types do not have the same device name.

5. Create a manifest from the Butane config and save it to the **clusterconfig/openshift** directory. For example, run the following command:

```
$ butane $HOME/clusterconfig/98-var-partition.bu -o $HOME/clusterconfig/openshift/98-var-partition.yaml
```

6. Run **openshift-install** again to create Ignition configs from a set of files in the **manifest** and **openshift** subdirectories:

```
$ openshift-install create ignition-configs --dir $HOME/clusterconfig
$ ls $HOME/clusterconfig/
auth  bootstrap.ign  master.ign  metadata.json  worker.ign
```

Now you can use the Ignition config files as input to the installation procedures to install Red Hat Enterprise Linux CoreOS (RHCOS) systems.

6.11.8.2. Creating the installation configuration file

You can customize the OpenShift Container Platform cluster you install on Microsoft Azure.

Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.
- Obtain service principal permissions at the subscription level.

Procedure

1. Create the **install-config.yaml** file.
   a. Change to the directory that contains the installation program and run the following command:

```
$ ./openshift-install create install-config --dir <installation_directory> 1
```

   1 For **<installation_directory>**, specify the directory name to store the files that the installation program creates.

   When specifying the directory:

   - Verify that the directory has the **execute** permission. This permission is required to run Terraform binaries under the installation directory.
   - Use an empty directory. Some installation assets, such as bootstrap X.509 certificates, have short expiration intervals, therefore you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

   b. At the prompts, provide the configuration details for your cloud:
      i. Optional: Select an SSH key to use to access your cluster machines.

NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

      ii. Select **azure** as the platform to target.
      iii. If you do not have a Microsoft Azure profile stored on your computer, specify the following Azure parameter values for your subscription and service principal:
         - **azure subscription id** The subscription ID to use for the cluster. Specify the **id** value in your account output.
         - **azure tenant id** The tenant ID. Specify the **tenantId** value in your account output.
         - **azure service principal client id** The value of the **appId** parameter for the service principal.
         - **azure service principal client secret** The value of the **password** parameter for the service principal.

iv. Select the region to deploy the cluster to.

v. Select the base domain to deploy the cluster to. The base domain corresponds to the Azure DNS Zone that you created for your cluster.

vi. Enter a descriptive name for your cluster.

IMPORTANT

All Azure resources that are available through public endpoints are subject to resource name restrictions, and you cannot create resources that use certain terms. For a list of terms that Azure restricts, see Resolve reserved resource name errors in the Azure documentation.

vii. Paste the pull secret from the Red Hat OpenShift Cluster Manager .

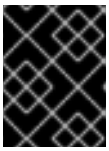
c. Optional: If you do not want the cluster to provision compute machines, empty the compute pool by editing the resulting **install-config.yaml** file to set **replicas** to **0** for the **compute** pool:

```
compute:
- hyperthreading: Enabled
  name: worker
  platform: {}
  replicas: 0 1
```

1 Set to **0**.

2. Modify the **install-config.yaml** file. You can find more information about the available parameters in the "Installation configuration parameters" section.

3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.



IMPORTANT

The **install-config.yaml** file is consumed during the installation process. If you want to reuse the file, you must back it up now.

6.11.8.3. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.

NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

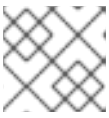
For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
```

1. A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
2. A proxy URL to use for creating HTTPS connections outside the cluster.
3. A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use ***** to bypass the proxy for all destinations.
4. If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace that contains one or more additional CA certificates that are required for proxying HTTPS connections. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges these contents with the Red Hat Enterprise Linux CoreOS (RHCOS) trust bundle, and this config map is referenced in the **trustedCA** field of the **Proxy** object. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.



NOTE

The installation program does not support the proxy **readinessEndpoints** field.

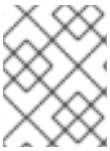
NOTE

If the installer times out, restart and then complete the deployment by using the **wait-for** command of the installer. For example:

```
$ ./openshift-install wait-for install-complete --log-level debug
```

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.



NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

6.11.8.4. Exporting common variables for ARM templates

You must export a common set of variables that are used with the provided Azure Resource Manager (ARM) templates used to assist in completing a user-provided infrastructure install on Microsoft Azure.

NOTE

Specific ARM templates can also require additional exported variables, which are detailed in their related procedures.

Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.

Procedure

1. Export common variables found in the **install-config.yaml** to be used by the provided ARM templates:

```
$ export CLUSTER_NAME=<cluster_name> 1
$ export AZURE_REGION=<azure_region> 2
$ export SSH_KEY=<ssh_key> 3
$ export BASE_DOMAIN=<base_domain> 4
$ export BASE_DOMAIN_RESOURCE_GROUP=<base_domain_resource_group> 5
```

1. The value of the **.metadata.name** attribute from the **install-config.yaml** file.
2. The region to deploy the cluster into, for example **centralus**. This is the value of the **.platform.azure.region** attribute from the **install-config.yaml** file.
3. The SSH RSA public key file as a string. You must enclose the SSH key in quotes since it contains spaces. This is the value of the **.sshKey** attribute from the **install-config.yaml** file.

4 The base domain to deploy the cluster to. The base domain corresponds to the public DNS zone that you created for your cluster. This is the value of the **.baseDomain** attribute

5 The resource group where the public DNS zone exists. This is the value of the **.platform.azure.baseDomainResourceGroupName** attribute from the **install-config.yaml** file.

For example:

```
$ export CLUSTER_NAME=test-cluster
$ export AZURE_REGION=centralus
$ export SSH_KEY="ssh-rsa xxx/xxx/xxx= user@email.com"
$ export BASE_DOMAIN=example.com
$ export BASE_DOMAIN_RESOURCE_GROUP=ocp-cluster
```

2. Export the kubeadmin credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

6.11.8.5. Creating the Kubernetes manifest and Ignition config files

Because you must modify some cluster definition files and manually start the cluster machines, you must generate the Kubernetes manifest and Ignition config files that the cluster needs to configure the machines.

The installation configuration file transforms into the Kubernetes manifests. The manifests wrap into the Ignition configuration files, which are later used to configure the cluster machines.

IMPORTANT

- The Ignition config files that the OpenShift Container Platform installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

Prerequisites

- You obtained the OpenShift Container Platform installation program.
- You created the **install-config.yaml** installation configuration file.

Procedure

1. Change to the directory that contains the OpenShift Container Platform installation program and generate the Kubernetes manifests for the cluster:

```
$ ./openshift-install create manifests --dir <installation_directory> 1
```

1 For **<installation_directory>**, specify the installation directory that contains the **install-config.yaml** file you created.

2. Remove the Kubernetes manifest files that define the control plane machines:

```
$ rm -f <installation_directory>/openshift/99_openshift-cluster-api_master-machines-*.yaml
```

By removing these files, you prevent the cluster from automatically generating control plane machines.

3. Remove the Kubernetes manifest files that define the worker machines:

```
$ rm -f <installation_directory>/openshift/99_openshift-cluster-api_worker-machineset-*.yaml
```

Because you create and manage the worker machines yourself, you do not need to initialize these machines.

4. Check that the **mastersSchedulable** parameter in the **<installation_directory>/manifests/cluster-scheduler-02-config.yml** Kubernetes manifest file is set to **false**. This setting prevents pods from being scheduled on the control plane machines:

   a. Open the **<installation_directory>/manifests/cluster-scheduler-02-config.yml** file.

   b. Locate the **mastersSchedulable** parameter and ensure that it is set to **false**.

   c. Save and exit the file.

5. Optional: If you do not want the Ingress Operator to create DNS records on your behalf, remove the **privateZone** and **publicZone** sections from the **<installation_directory>/manifests/cluster-dns-02-config.yml** DNS configuration file:

```
apiVersion: config.openshift.io/v1
kind: DNS
metadata:
  creationTimestamp: null
  name: cluster
spec:
  baseDomain: example.openshift.com
  privateZone: 1
    id: mycluster-100419-private-zone
  publicZone: 2
    id: example.openshift.com
status: {}
```

1 2 Remove this section completely.

If you do so, you must add ingress DNS records manually in a later step.

6. When configuring Azure on user-provisioned infrastructure, you must export some common variables defined in the manifest files to use later in the Azure Resource Manager (ARM) templates:

   a. Export the infrastructure ID by using the following command:

```
$ export INFRA_ID=<infra_id> 1
```

   1 The OpenShift Container Platform cluster has been assigned an identifier (**INFRA_ID**) in the form of **<cluster_name>-<random_string>**. This will be used as the base name for most resources created using the provided ARM templates. This is the value of the **.status.infrastructureName** attribute from the **manifests/cluster-infrastructure-02-config.yml** file.

   b. Export the resource group by using the following command:

```
$ export RESOURCE_GROUP=<resource_group> 1
```

   1 All resources created in this Azure deployment exists as part of a resource group. The resource group name is also based on the **INFRA_ID**, in the form of **<cluster_name>-<random_string>-rg**. This is the value of the **.status.platformStatus.azure.resourceGroupName** attribute from the **manifests/cluster-infrastructure-02-config.yml** file.

7. To create the Ignition configuration files, run the following command from the directory that contains the installation program:

```
$ ./openshift-install create ignition-configs --dir <installation_directory> 1
```

   1 For **<installation_directory>**, specify the same installation directory.

   Ignition config files are created for the bootstrap, control plane, and compute nodes in the installation directory. The **kubeadmin-password** and **kubeconfig** files are created in the **./<installation_directory>/auth** directory:

```
.
├── auth
│   ├── kubeadmin-password
│   └── kubeconfig
├── bootstrap.ign
├── master.ign
├── metadata.json
└── worker.ign
```

6.11.9. Creating the Azure resource group

You must create a Microsoft Azure resource group and an identity for that resource group. These are both used during the installation of your OpenShift Container Platform cluster on Azure.

Prerequisites

- Configure an Azure account.
- Generate the Ignition config files for your cluster.

Procedure

1. Create the resource group in a supported Azure region:

```
$ az group create --name ${RESOURCE_GROUP} --location ${AZURE_REGION}
```

2. Create an Azure identity for the resource group:

```
$ az identity create -g ${RESOURCE_GROUP} -n ${INFRA_ID}-identity
```

   This is used to grant the required access to Operators in your cluster. For example, this allows the Ingress Operator to create a public IP and its load balancer. You must assign the Azure identity to a role.

3. Grant the Contributor role to the Azure identity:

   a. Export the following variables required by the Azure role assignment:

```
$ export PRINCIPAL_ID=`az identity show -g ${RESOURCE_GROUP} -n ${INFRA_ID}-identity --query principalId --out tsv`
```

```
$ export RESOURCE_GROUP_ID=`az group show -g ${RESOURCE_GROUP} --query id --out tsv`
```

   b. Assign the Contributor role to the identity:

```
$ az role assignment create --assignee "${PRINCIPAL_ID}" --role 'Contributor' --scope "${RESOURCE_GROUP_ID}"
```

6.11.10. Uploading the RHCOS cluster image and bootstrap Ignition config file

The Azure client does not support deployments based on files existing locally. You must copy and store the RHCOS virtual hard disk (VHD) cluster image and bootstrap Ignition config file in a storage container so they are accessible during deployment.

Prerequisites

- Configure an Azure account.
- Generate the Ignition config files for your cluster.

Procedure

1. Create an Azure storage account to store the VHD cluster image:

```
$ az storage account create -g ${RESOURCE_GROUP} --location ${AZURE_REGION} --name ${CLUSTER_NAME}sa --kind Storage --sku Standard_LRS
```

WARNING

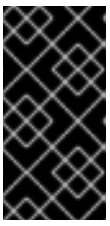
The Azure storage account name must be between 3 and 24 characters in length and use numbers and lower-case letters only. If your **CLUSTER_NAME** variable does not follow these restrictions, you must manually define the Azure storage account name. For more information on Azure storage account name restrictions, see Resolve errors for storage account names in the Azure documentation.

2. Export the storage account key as an environment variable:

```
$ export ACCOUNT_KEY=`az storage account keys list -g ${RESOURCE_GROUP} --
account-name ${CLUSTER_NAME}sa --query "[0].value" -o tsv`
```

3. Export the URL of the RHCOS VHD to an environment variable:

```
$ export VHD_URL=`openshift-install coreos print-stream-json | jq -r
'.architectures.x86_64."rhel-coreos-extensions"."azure-disk".url'`
```



IMPORTANT

The RHCOS images might not change with every release of OpenShift Container Platform. You must specify an image with the highest version that is less than or equal to the OpenShift Container Platform version that you install. Use the image version that matches your OpenShift Container Platform version if it is available.

4. Create the storage container for the VHD:

```
$ az storage container create --name vhd --account-name ${CLUSTER_NAME}sa --account-
key ${ACCOUNT_KEY}
```

5. Copy the local VHD to a blob:

```
$ az storage blob copy start --account-name ${CLUSTER_NAME}sa --account-key
${ACCOUNT_KEY} --destination-blob "rhcos.vhd" --destination-container vhd --source-uri
"${VHD_URL}"
```

6. Create a blob storage container and upload the generated **bootstrap.ign** file:

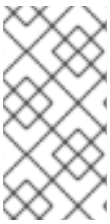
```
$ az storage container create --name files --account-name ${CLUSTER_NAME}sa --
account-key ${ACCOUNT_KEY}
```

```
$ az storage blob upload --account-name ${CLUSTER_NAME}sa --account-key
${ACCOUNT_KEY} -c "files" -f "<installation_directory>/bootstrap.ign" -n "bootstrap.ign"
```

6.11.11. Example for creating DNS zones

DNS records are required for clusters that use user-provisioned infrastructure. You should choose the DNS strategy that fits your scenario.

For this example, Azure's DNS solution is used, so you will create a new public DNS zone for external (internet) visibility and a private DNS zone for internal cluster resolution.



NOTE

The public DNS zone is not required to exist in the same resource group as the cluster deployment and might already exist in your organization for the desired base domain. If that is the case, you can skip creating the public DNS zone; be sure the installation config you generated earlier reflects that scenario.

Prerequisites

- Configure an Azure account.
- Generate the Ignition config files for your cluster.

Procedure

1. Create the new public DNS zone in the resource group exported in the **BASE_DOMAIN_RESOURCE_GROUP** environment variable:

```
$ az network dns zone create -g ${BASE_DOMAIN_RESOURCE_GROUP} -n
${CLUSTER_NAME}.${BASE_DOMAIN}
```

   You can skip this step if you are using a public DNS zone that already exists.

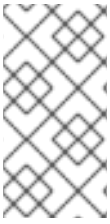
2. Create the private DNS zone in the same resource group as the rest of this deployment:

```
$ az network private-dns zone create -g ${RESOURCE_GROUP} -n
${CLUSTER_NAME}.${BASE_DOMAIN}
```

You can learn more about configuring a public DNS zone in Azure by visiting that section.

6.11.12. Creating a VNet in Azure

You must create a virtual network (VNet) in Microsoft Azure for your OpenShift Container Platform cluster to use. You can customize the VNet to meet your requirements. One way to create the VNet is to modify the provided Azure Resource Manager (ARM) template.



NOTE

If you do not use the provided ARM template to create your Azure infrastructure, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

Prerequisites

- Configure an Azure account.
- Generate the Ignition config files for your cluster.

Procedure

1. Copy the template from the **ARM template for the VNet**section of this topic and save it as **01_vnet.json** in your cluster's installation directory. This template describes the VNet that your cluster requires.

2. Create the deployment by using the **az** CLI:

```
$ az deployment group create -g ${RESOURCE_GROUP} \
  --template-file "<installation_directory>/01_vnet.json" \
  --parameters baseName="${INFRA_ID}" 1
```

1 The base name to be used in resource names; this is usually the cluster's infrastructure ID.

3. Link the VNet template to the private DNS zone:

```
$ az network private-dns link vnet create -g ${RESOURCE_GROUP} -z
${CLUSTER_NAME}.${BASE_DOMAIN} -n ${INFRA_ID}-network-link -v "${INFRA_ID}-vnet"
-e false
```

6.11.12.1. ARM template for the VNet

You can use the following Azure Resource Manager (ARM) template to deploy the VNet that you need for your OpenShift Container Platform cluster:

Example 6.7. 01_vnet.json ARM template

```
{
  "$schema" : "https://schema.management.azure.com/schemas/2015-01-
01/deploymentTemplate.json#",
  "contentVersion" : "1.0.0.0",
  "parameters" : {
    "baseName" : {
      "type" : "string",
      "minLength" : 1,
      "metadata" : {
        "description" : "Base name to be used in resource names (usually the cluster's Infra ID)"
      }
    }
  },
  "variables" : {
    "location" : "[resourceGroup().location]",
    "virtualNetworkName" : "[concat(parameters('baseName'), '-vnet')]",
    "addressPrefix" : "10.0.0.0/16",
    "masterSubnetName" : "[concat(parameters('baseName'), '-master-subnet')]",
    "masterSubnetPrefix" : "10.0.0.0/24",
    "nodeSubnetName" : "[concat(parameters('baseName'), '-worker-subnet')]",
    "nodeSubnetPrefix" : "10.0.1.0/24",
    "clusterNsgName" : "[concat(parameters('baseName'), '-nsg')]"
  },
  "resources" : [
    {
      "apiVersion" : "2018-12-01",
      "type" : "Microsoft.Network/virtualNetworks",
```

```
      "name" : "[variables('virtualNetworkName')]",
      "location" : "[variables('location')]",
      "dependsOn" : [
        "[concat('Microsoft.Network/networkSecurityGroups/', variables('clusterNsgName'))]"
      ],
      "properties" : {
        "addressSpace" : {
          "addressPrefixes" : [
            "[variables('addressPrefix')]"
          ]
        },
        "subnets" : [
          {
            "name" : "[variables('masterSubnetName')]",
            "properties" : {
              "addressPrefix" : "[variables('masterSubnetPrefix')]",
              "serviceEndpoints": [],
              "networkSecurityGroup" : {
                "id" : "[resourceId('Microsoft.Network/networkSecurityGroups',
variables('clusterNsgName'))]"
              }
            }
          },
          {
            "name" : "[variables('nodeSubnetName')]",
            "properties" : {
              "addressPrefix" : "[variables('nodeSubnetPrefix')]",
              "serviceEndpoints": [],
              "networkSecurityGroup" : {
                "id" : "[resourceId('Microsoft.Network/networkSecurityGroups',
variables('clusterNsgName'))]"
              }
            }
          }
        ]
      }
    },
    {
      "type" : "Microsoft.Network/networkSecurityGroups",
      "name" : "[variables('clusterNsgName')]",
      "apiVersion" : "2018-10-01",
      "location" : "[variables('location')]",
      "properties" : {
        "securityRules" : [
          {
            "name" : "apiserver_in",
            "properties" : {
              "protocol" : "Tcp",
              "sourcePortRange" : "*",
              "destinationPortRange" : "6443",
              "sourceAddressPrefix" : "*",
              "destinationAddressPrefix" : "*",
              "access" : "Allow",
              "priority" : 101,
              "direction" : "Inbound"
            }
```

```
        }
      ]
    }
  }
 ]
}
```

6.11.13. Deploying the RHCOS cluster image for the Azure infrastructure

You must use a valid Red Hat Enterprise Linux CoreOS (RHCOS) image for Microsoft Azure for your OpenShift Container Platform nodes.

Prerequisites

- Configure an Azure account.
- Generate the Ignition config files for your cluster.
- Store the RHCOS virtual hard disk (VHD) cluster image in an Azure storage container.
- Store the bootstrap Ignition config file in an Azure storage container.

Procedure

1. Copy the template from the **ARM template for image storage**section of this topic and save it as **02_storage.json** in your cluster's installation directory. This template describes the image storage that your cluster requires.
2. Export the RHCOS VHD blob URL as a variable:

```
$ export VHD_BLOB_URL=`az storage blob url --account-name ${CLUSTER_NAME}sa --
account-key ${ACCOUNT_KEY} -c vhd -n "rhcos.vhd" -o tsv`
```

3. Deploy the cluster image:

```
$ az deployment group create -g ${RESOURCE_GROUP} \
  --template-file "<installation_directory>/02_storage.json" \
  --parameters vhdBlobURL="${VHD_BLOB_URL}" \ 1
  --parameters baseName="${INFRA_ID}" 2
```

1. The blob URL of the RHCOS VHD to be used to create master and worker machines.
2. The base name to be used in resource names; this is usually the cluster's infrastructure ID.

6.11.13.1. ARM template for image storage

You can use the following Azure Resource Manager (ARM) template to deploy the stored Red Hat Enterprise Linux CoreOS (RHCOS) image that you need for your OpenShift Container Platform cluster:

Example 6.8. 02_storage.json ARM template

```
{
  "$schema" : "https://schema.management.azure.com/schemas/2015-01-
01/deploymentTemplate.json#",
  "contentVersion" : "1.0.0.0",
  "parameters" : {
    "baseName" : {
      "type" : "string",
      "minLength" : 1,
      "metadata" : {
        "description" : "Base name to be used in resource names (usually the cluster's Infra ID)"
      }
    },
    "vhdBlobURL" : {
      "type" : "string",
      "metadata" : {
        "description" : "URL pointing to the blob where the VHD to be used to create master and
worker machines is located"
      }
    }
  },
  "variables" : {
    "location" : "[resourceGroup().location]",
    "imageName" : "[concat(parameters('baseName'), '-image')]",
    "imageNameGen2" : "[concat(parameters('baseName'), '-gen2')]"
  },
  "resources" : [
    {
      "apiVersion" : "2018-06-01",
      "type": "Microsoft.Compute/images",
      "name": "[variables('imageName')]",
      "location" : "[variables('location')]",
      "properties": {
        "storageProfile": {
          "osDisk": {
            "osType": "Linux",
            "osState": "Generalized",
            "blobUri": "[parameters('vhdBlobURL')]",
            "storageAccountType": "Standard_LRS"
          }
        }
      }
    },
    {
      "apiVersion": "2020-12-01",
      "type": "Microsoft.Compute/images",
      "name": "[variables('imageNameGen2')]",
      "location": "[variables('location')]",
      "properties": {
        "hyperVGeneration": "V2",
        "storageProfile": {
          "osDisk": {
            "osType": "Linux",
            "osState": "Generalized",
            "blobUri": "[parameters('vhdBlobURL')]",
            "storageAccountType": "Standard_LRS"
          }
```

```
        }
      }
    }
  ]
}
```

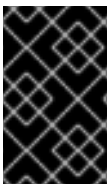
6.11.14. Networking requirements for user-provisioned infrastructure

All the Red Hat Enterprise Linux CoreOS (RHCOS) machines require networking to be configured in **initramfs** during boot to fetch their Ignition config files.

6.11.14.1. Network connectivity requirements

You must configure the network connectivity between machines to allow OpenShift Container Platform cluster components to communicate. Each machine must be able to resolve the hostnames of all other machines in the cluster.

This section provides details about the ports that are required.



IMPORTANT

In connected OpenShift Container Platform environments, all nodes are required to have internet access to pull images for platform containers and provide telemetry data to Red Hat.

Table 6.38. Ports used for all-machine to all-machine communications

Protocol	Port	Description
ICMP	N/A	Network reachability tests
TCP	**1936**	Metrics
	9000-**9999**	Host level services, including the node exporter on ports **9100**-**9101** and the Cluster Version Operator on port**9099**.
	10250-**10259**	The default ports that Kubernetes reserves
	10256	openshift-sdn
UDP	**4789**	VXLAN
	6081	Geneve
	9000-**9999**	Host level services, including the node exporter on ports **9100**-**9101**.
	500	IPsec IKE packets

Protocol	Port	Description
	4500	IPsec NAT-T packets
TCP/UDP	**30000**-**32767**	Kubernetes node port
ESP	N/A	IPsec Encapsulating Security Payload (ESP)

Table 6.39. Ports used for all-machine to control plane communications

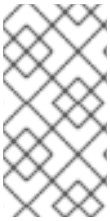
Protocol	Port	Description
TCP	**6443**	Kubernetes API

Table 6.40. Ports used for control plane machine to control plane machine communications

Protocol	Port	Description
TCP	**2379**-**2380**	etcd server and peer ports

6.11.15. Creating networking and load balancing components in Azure

You must configure networking and load balancing in Microsoft Azure for your OpenShift Container Platform cluster to use. One way to create these components is to modify the provided Azure Resource Manager (ARM) template.



NOTE

If you do not use the provided ARM template to create your Azure infrastructure, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

Prerequisites

- Configure an Azure account.
- Generate the Ignition config files for your cluster.
- Create and configure a VNet and associated subnets in Azure.

Procedure

1. Copy the template from the **ARM template for the network and load balancers**section of this topic and save it as **03_infra.json** in your cluster's installation directory. This template describes the networking and load balancing objects that your cluster requires.
2. Create the deployment by using the **az** CLI:

```
$ az deployment group create -g ${RESOURCE_GROUP} \
```

```
--template-file "<installation_directory>/03_infra.json" \
--parameters privateDNSZoneName="${CLUSTER_NAME}.${BASE_DOMAIN}" \ 1
--parameters baseName="${INFRA_ID}" 2
```

1 The name of the private DNS zone.

2 The base name to be used in resource names; this is usually the cluster's infrastructure ID.

3. Create an **api** DNS record in the public zone for the API public load balancer. The **${BASE_DOMAIN_RESOURCE_GROUP}** variable must point to the resource group where the public DNS zone exists.

   a. Export the following variable:

   ```
   $ export PUBLIC_IP=`az network public-ip list -g ${RESOURCE_GROUP} --query "[?name=='${INFRA_ID}-master-pip'] | [0].ipAddress" -o tsv`
   ```

   b. Create the **api** DNS record in a new public zone:

   ```
   $ az network dns record-set a add-record -g ${BASE_DOMAIN_RESOURCE_GROUP} -z ${CLUSTER_NAME}.${BASE_DOMAIN} -n api -a ${PUBLIC_IP} --ttl 60
   ```

   If you are adding the cluster to an existing public zone, you can create the **api** DNS record in it instead:

   ```
   $ az network dns record-set a add-record -g ${BASE_DOMAIN_RESOURCE_GROUP} -z ${BASE_DOMAIN} -n api.${CLUSTER_NAME} -a ${PUBLIC_IP} --ttl 60
   ```

6.11.15.1. ARM template for the network and load balancers

You can use the following Azure Resource Manager (ARM) template to deploy the networking objects and load balancers that you need for your OpenShift Container Platform cluster:

Example 6.9. 03_infra.json ARM template

```
{
  "$schema" : "https://schema.management.azure.com/schemas/2015-01-01/deploymentTemplate.json#",
  "contentVersion" : "1.0.0.0",
  "parameters" : {
    "baseName" : {
      "type" : "string",
      "minLength" : 1,
      "metadata" : {
        "description" : "Base name to be used in resource names (usually the cluster's Infra ID)"
      }
    },
    "vnetBaseName": {
      "type": "string",
      "defaultValue": "",
      "metadata" : {
        "description" : "The specific customer vnet's base name (optional)"
      }
```

```
    },
    "privateDNSZoneName" : {
      "type" : "string",
      "metadata" : {
        "description" : "Name of the private DNS zone"
      }
    }
  },
  "variables" : {
    "location" : "[resourceGroup().location]",
    "virtualNetworkName" : "[concat(if(not(empty(parameters('vnetBaseName'))),
parameters('vnetBaseName'), parameters('baseName')), '-vnet')]",
    "virtualNetworkID" : "[resourceId('Microsoft.Network/virtualNetworks',
variables('virtualNetworkName'))]",
    "masterSubnetName" : "[concat(if(not(empty(parameters('vnetBaseName'))),
parameters('vnetBaseName'), parameters('baseName')), '-master-subnet')]",
    "masterSubnetRef" : "[concat(variables('virtualNetworkID'), '/subnets/',
variables('masterSubnetName'))]",
    "masterPublicIpAddressName" : "[concat(parameters('baseName'), '-master-pip')]",
    "masterPublicIpAddressID" : "[resourceId('Microsoft.Network/publicIPAddresses',
variables('masterPublicIpAddressName'))]",
    "masterLoadBalancerName" : "[concat(parameters('baseName'), '-public-lb')]",
    "masterLoadBalancerID" : "[resourceId('Microsoft.Network/loadBalancers',
variables('masterLoadBalancerName'))]",
    "internalLoadBalancerName" : "[concat(parameters('baseName'), '-internal-lb')]",
    "internalLoadBalancerID" : "[resourceId('Microsoft.Network/loadBalancers',
variables('internalLoadBalancerName'))]",
    "skuName": "Standard"
  },
  "resources" : [
    {
      "apiVersion" : "2018-12-01",
      "type" : "Microsoft.Network/publicIPAddresses",
      "name" : "[variables('masterPublicIpAddressName')]",
      "location" : "[variables('location')]",
      "sku": {
        "name": "[variables('skuName')]"
      },
      "properties" : {
        "publicIPAllocationMethod" : "Static",
        "dnsSettings" : {
          "domainNameLabel" : "[variables('masterPublicIpAddressName')]"
        }
      }
    },
    {
      "apiVersion" : "2018-12-01",
      "type" : "Microsoft.Network/loadBalancers",
      "name" : "[variables('masterLoadBalancerName')]",
      "location" : "[variables('location')]",
      "sku": {
        "name": "[variables('skuName')]"
      },
      "dependsOn" : [
        "[concat('Microsoft.Network/publicIPAddresses/', variables('masterPublicIpAddressName'))]"
      ],
```

```
    "properties" : {
     "frontendIPConfigurations" : [
      {
       "name" : "public-lb-ip",
       "properties" : {
        "publicIPAddress" : {
         "id" : "[variables('masterPublicIpAddressID')]"
        }
       }
      }
     ],
     "backendAddressPools" : [
      {
       "name" : "public-lb-backend"
      }
     ],
     "loadBalancingRules" : [
      {
       "name" : "api-internal",
       "properties" : {
        "frontendIPConfiguration" : {
         "id" :"[concat(variables('masterLoadBalancerID'), '/frontendIPConfigurations/public-lb-
ip')]"
        },
        "backendAddressPool" : {
         "id" : "[concat(variables('masterLoadBalancerID'), '/backendAddressPools/public-lb-
backend')]"
        },
        "protocol" : "Tcp",
        "loadDistribution" : "Default",
        "idleTimeoutInMinutes" : 30,
        "frontendPort" : 6443,
        "backendPort" : 6443,
        "probe" : {
         "id" : "[concat(variables('masterLoadBalancerID'), '/probes/api-internal-probe')]"
        }
       }
      }
     ],
     "probes" : [
      {
       "name" : "api-internal-probe",
       "properties" : {
        "protocol" : "Https",
        "port" : 6443,
        "requestPath": "/readyz",
        "intervalInSeconds" : 10,
        "numberOfProbes" : 3
       }
      }
     ]
    }
   },
   {
    "apiVersion" : "2018-12-01",
    "type" : "Microsoft.Network/loadBalancers",
```

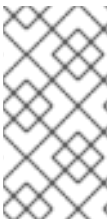
```
    "name" : "[variables('internalLoadBalancerName')]",
    "location" : "[variables('location')]",
    "sku": {
      "name": "[variables('skuName')]"
    },
    "properties" : {
      "frontendIPConfigurations" : [
        {
          "name" : "internal-lb-ip",
          "properties" : {
            "privateIPAllocationMethod" : "Dynamic",
            "subnet" : {
              "id" : "[variables('masterSubnetRef')]"
            },
            "privateIPAddressVersion" : "IPv4"
          }
        }
      ],
      "backendAddressPools" : [
        {
          "name" : "internal-lb-backend"
        }
      ],
      "loadBalancingRules" : [
        {
          "name" : "api-internal",
          "properties" : {
            "frontendIPConfiguration" : {
              "id" : "[concat(variables('internalLoadBalancerID'), '/frontendIPConfigurations/internal-lb-
ip')]"
            },
            "frontendPort" : 6443,
            "backendPort" : 6443,
            "enableFloatingIP" : false,
            "idleTimeoutInMinutes" : 30,
            "protocol" : "Tcp",
            "enableTcpReset" : false,
            "loadDistribution" : "Default",
            "backendAddressPool" : {
              "id" : "[concat(variables('internalLoadBalancerID'), '/backendAddressPools/internal-lb-
backend')]"
            },
            "probe" : {
              "id" : "[concat(variables('internalLoadBalancerID'), '/probes/api-internal-probe')]"
            }
          }
        },
        {
          "name" : "sint",
          "properties" : {
            "frontendIPConfiguration" : {
              "id" : "[concat(variables('internalLoadBalancerID'), '/frontendIPConfigurations/internal-lb-
ip')]"
            },
            "frontendPort" : 22623,
            "backendPort" : 22623,
```

```
            "enableFloatingIP" : false,
            "idleTimeoutInMinutes" : 30,
            "protocol" : "Tcp",
            "enableTcpReset" : false,
            "loadDistribution" : "Default",
            "backendAddressPool" : {
              "id" : "[concat(variables('internalLoadBalancerID'), '/backendAddressPools/internal-lb-backend')]"
            },
            "probe" : {
              "id" : "[concat(variables('internalLoadBalancerID'), '/probes/sint-probe')]"
            }
          }
        }
      ],
      "probes" : [
        {
          "name" : "api-internal-probe",
          "properties" : {
            "protocol" : "Https",
            "port" : 6443,
            "requestPath": "/readyz",
            "intervalInSeconds" : 10,
            "numberOfProbes" : 3
          }
        },
        {
          "name" : "sint-probe",
          "properties" : {
            "protocol" : "Https",
            "port" : 22623,
            "requestPath": "/healthz",
            "intervalInSeconds" : 10,
            "numberOfProbes" : 3
          }
        }
      ]
    }
  },
  {
    "apiVersion": "2018-09-01",
    "type": "Microsoft.Network/privateDnsZones/A",
    "name": "[concat(parameters('privateDNSZoneName'), '/api')]",
    "location" : "[variables('location')]",
    "dependsOn" : [
      "[concat('Microsoft.Network/loadBalancers/', variables('internalLoadBalancerName'))]"
    ],
    "properties": {
      "ttl": 60,
      "aRecords": [
        {
          "ipv4Address": "[reference(variables('internalLoadBalancerName')).frontendIPConfigurations[0].properties.privateIPAddress]"
        }
      ]
```

```
      }
    },
    {
      "apiVersion": "2018-09-01",
      "type": "Microsoft.Network/privateDnsZones/A",
      "name": "[concat(parameters('privateDNSZoneName'), '/api-int')]",
      "location" : "[variables('location')]",
      "dependsOn" : [
        "[concat('Microsoft.Network/loadBalancers/', variables('internalLoadBalancerName'))]"
      ],
      "properties": {
        "ttl": 60,
        "aRecords": [
          {
            "ipv4Address": "
[reference(variables('internalLoadBalancerName')).frontendIPConfigurations[0].properties.privateIP
Address]"
          }
        ]
      }
    }
  ]
}
```

6.11.16. Creating the bootstrap machine in Azure

You must create the bootstrap machine in Microsoft Azure to use during OpenShift Container Platform cluster initialization. One way to create this machine is to modify the provided Azure Resource Manager (ARM) template.



NOTE

If you do not use the provided ARM template to create your bootstrap machine, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

Prerequisites

- Configure an Azure account.
- Generate the Ignition config files for your cluster.
- Create and configure a VNet and associated subnets in Azure.
- Create and configure networking and load balancers in Azure.
- Create control plane and compute roles.

Procedure

1. Copy the template from the **ARM template for the bootstrap machine**section of this topic and save it as **04_bootstrap.json** in your cluster's installation directory. This template describes the bootstrap machine that your cluster requires.

2. Export the bootstrap URL variable:

```
$ bootstrap_url_expiry=`date -u -d "10 hours" '+%Y-%m-%dT%H:%MZ'`
```

```
$ export BOOTSTRAP_URL=`az storage blob generate-sas -c 'files' -n 'bootstrap.ign' --https-only --full-uri --permissions r --expiry $bootstrap_url_expiry --account-name ${CLUSTER_NAME}sa --account-key ${ACCOUNT_KEY} -o tsv`
```

3. Export the bootstrap ignition variable:

```
$ export BOOTSTRAP_IGNITION=`jq -rcnM --arg v "3.2.0" --arg url ${BOOTSTRAP_URL} '{ignition:{version:$v,config:{replace:{source:$url}}}}' | base64 | tr -d '\n'`
```

4. Create the deployment by using the **az** CLI:

```
$ az deployment group create -g ${RESOURCE_GROUP} \
  --template-file "<installation_directory>/04_bootstrap.json" \
  --parameters bootstrapIgnition="${BOOTSTRAP_IGNITION}" \ 1
  --parameters baseName="${INFRA_ID}" 2
```

1. The bootstrap Ignition content for the bootstrap cluster.
2. The base name to be used in resource names; this is usually the cluster's infrastructure ID.

6.11.16.1. ARM template for the bootstrap machine

You can use the following Azure Resource Manager (ARM) template to deploy the bootstrap machine that you need for your OpenShift Container Platform cluster:

Example 6.10. 04_bootstrap.json ARM template

```
{
  "$schema" : "https://schema.management.azure.com/schemas/2015-01-01/deploymentTemplate.json#",
  "contentVersion" : "1.0.0.0",
  "parameters" : {
    "baseName" : {
      "type" : "string",
      "minLength" : 1,
      "metadata" : {
        "description" : "Base name to be used in resource names (usually the cluster's Infra ID)"
      }
    },
    "vnetBaseName": {
      "type": "string",
      "defaultValue": "",
      "metadata" : {
        "description" : "The specific customer vnet's base name (optional)"
      }
    },
    "bootstrapIgnition" : {
      "type" : "string",
      "minLength" : 1,
```

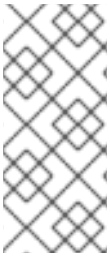
```
      "metadata" : {
        "description" : "Bootstrap ignition content for the bootstrap cluster"
      }
    },
    "sshKeyData" : {
      "type" : "securestring",
      "defaultValue" : "Unused",
      "metadata" : {
        "description" : "Unused"
      }
    },
    "bootstrapVMSize" : {
      "type" : "string",
      "defaultValue" : "Standard_D4s_v3",
      "metadata" : {
        "description" : "The size of the Bootstrap Virtual Machine"
      }
    }
  },
  "variables" : {
    "location" : "[resourceGroup().location]",
    "virtualNetworkName" : "[concat(if(not(empty(parameters('vnetBaseName'))),
parameters('vnetBaseName'), parameters('baseName')), '-vnet')]",
    "virtualNetworkID" : "[resourceId('Microsoft.Network/virtualNetworks',
variables('virtualNetworkName'))]",
    "masterSubnetName" : "[concat(if(not(empty(parameters('vnetBaseName'))),
parameters('vnetBaseName'), parameters('baseName')), '-master-subnet')]",
    "masterSubnetRef" : "[concat(variables('virtualNetworkID'), '/subnets/',
variables('masterSubnetName'))]",
    "masterLoadBalancerName" : "[concat(parameters('baseName'), '-public-lb')]",
    "internalLoadBalancerName" : "[concat(parameters('baseName'), '-internal-lb')]",
    "sshKeyPath" : "/home/core/.ssh/authorized_keys",
    "identityName" : "[concat(parameters('baseName'), '-identity')]",
    "vmName" : "[concat(parameters('baseName'), '-bootstrap')]",
    "nicName" : "[concat(variables('vmName'), '-nic')]",
    "imageName" : "[concat(parameters('baseName'), '-image')]",
    "clusterNsgName" : "[concat(if(not(empty(parameters('vnetBaseName'))),
parameters('vnetBaseName'), parameters('baseName')), '-nsg')]",
    "sshPublicIpAddressName" : "[concat(variables('vmName'), '-ssh-pip')]"
  },
  "resources" : [
    {
      "apiVersion" : "2018-12-01",
      "type" : "Microsoft.Network/publicIPAddresses",
      "name" : "[variables('sshPublicIpAddressName')]",
      "location" : "[variables('location')]",
      "sku": {
        "name": "Standard"
      },
      "properties" : {
        "publicIPAllocationMethod" : "Static",
        "dnsSettings" : {
          "domainNameLabel" : "[variables('sshPublicIpAddressName')]"
        }
      }
    },
```

```
    {
      "apiVersion" : "2018-06-01",
      "type" : "Microsoft.Network/networkInterfaces",
      "name" : "[variables('nicName')]",
      "location" : "[variables('location')]",
      "dependsOn" : [
        "[resourceId('Microsoft.Network/publicIPAddresses', variables('sshPublicIpAddressName'))]"
      ],
      "properties" : {
        "ipConfigurations" : [
          {
            "name" : "pipConfig",
            "properties" : {
              "privateIPAllocationMethod" : "Dynamic",
              "publicIPAddress": {
                "id": "[resourceId('Microsoft.Network/publicIPAddresses',
variables('sshPublicIpAddressName'))]"
              },
              "subnet" : {
                "id" : "[variables('masterSubnetRef')]"
              },
              "loadBalancerBackendAddressPools" : [
                {
                  "id" : "[concat('/subscriptions/', subscription().subscriptionId, '/resourceGroups/',
resourceGroup().name, '/providers/Microsoft.Network/loadBalancers/',
variables('masterLoadBalancerName'), '/backendAddressPools/public-lb-backend')]"
                },
                {
                  "id" : "[concat('/subscriptions/', subscription().subscriptionId, '/resourceGroups/',
resourceGroup().name, '/providers/Microsoft.Network/loadBalancers/',
variables('internalLoadBalancerName'), '/backendAddressPools/internal-lb-backend')]"
                }
              ]
            }
          }
        ]
      }
    },
    {
      "apiVersion" : "2018-06-01",
      "type" : "Microsoft.Compute/virtualMachines",
      "name" : "[variables('vmName')]",
      "location" : "[variables('location')]",
      "identity" : {
        "type" : "userAssigned",
        "userAssignedIdentities" : {
          "[resourceID('Microsoft.ManagedIdentity/userAssignedIdentities/',
variables('identityName'))]" : {}
        }
      },
      "dependsOn" : [
        "[concat('Microsoft.Network/networkInterfaces/', variables('nicName'))]"
      ],
      "properties" : {
        "hardwareProfile" : {
          "vmSize" : "[parameters('bootstrapVMSize')]"
```

```
        },
        "osProfile" : {
          "computerName" : "[variables('vmName')]",
          "adminUsername" : "core",
          "adminPassword" : "NotActuallyApplied!",
          "customData" : "[parameters('bootstrapIgnition')]",
          "linuxConfiguration" : {
            "disablePasswordAuthentication" : false
          }
        },
        "storageProfile" : {
          "imageReference": {
            "id": "[resourceId('Microsoft.Compute/images', variables('imageName'))]"
          },
          "osDisk" : {
            "name": "[concat(variables('vmName'),'_OSDisk')]",
            "osType" : "Linux",
            "createOption" : "FromImage",
            "managedDisk": {
              "storageAccountType": "Premium_LRS"
            },
            "diskSizeGB" : 100
          }
        },
        "networkProfile" : {
          "networkInterfaces" : [
            {
              "id" : "[resourceId('Microsoft.Network/networkInterfaces', variables('nicName'))]"
            }
          ]
        }
      },
      {
        "apiVersion" : "2018-06-01",
        "type": "Microsoft.Network/networkSecurityGroups/securityRules",
        "name" : "[concat(variables('clusterNsgName'), '/bootstrap_ssh_in')]",
        "location" : "[variables('location')]",
        "dependsOn" : [
          "[resourceId('Microsoft.Compute/virtualMachines', variables('vmName'))]"
        ],
        "properties": {
          "protocol" : "Tcp",
          "sourcePortRange" : "*",
          "destinationPortRange" : "22",
          "sourceAddressPrefix" : "*",
          "destinationAddressPrefix" : "*",
          "access" : "Allow",
          "priority" : 100,
          "direction" : "Inbound"
        }
      }
    ]
}
```

6.11.17. Creating the control plane machines in Azure

You must create the control plane machines in Microsoft Azure for your cluster to use. One way to create these machines is to modify the provided Azure Resource Manager (ARM) template.



NOTE

By default, Microsoft Azure places control plane machines and compute machines in a pre-set availability zone. You can manually set an availability zone for a compute node or control plane node. To do this, modify a vendor's Azure Resource Manager (ARM) template by specifying each of your availability zones in the **zones** parameter of the virtual machine resource.

If you do not use the provided ARM template to create your control plane machines, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, consider contacting Red Hat support with your installation logs.

Prerequisites

- Configure an Azure account.
- Generate the Ignition config files for your cluster.
- Create and configure a VNet and associated subnets in Azure.
- Create and configure networking and load balancers in Azure.
- Create control plane and compute roles.
- Create the bootstrap machine.

Procedure

1. Copy the template from the **ARM template for control plane machines**section of this topic and save it as **05_masters.json** in your cluster's installation directory. This template describes the control plane machines that your cluster requires.
2. Export the following variable needed by the control plane machine deployment:

```
$ export MASTER_IGNITION=`cat <installation_directory>/master.ign | base64 | tr -d '\n'`
```

3. Create the deployment by using the **az** CLI:

```
$ az deployment group create -g ${RESOURCE_GROUP} \
  --template-file "<installation_directory>/05_masters.json" \
  --parameters masterIgnition="${MASTER_IGNITION}" \ 1
  --parameters baseName="${INFRA_ID}" 2
```

1. The Ignition content for the control plane nodes.
2. The base name to be used in resource names; this is usually the cluster's infrastructure ID.

6.11.17.1. ARM template for control plane machines

You can use the following Azure Resource Manager (ARM) template to deploy the control plane machines that you need for your OpenShift Container Platform cluster:

Example 6.11. 05_masters.json ARM template

```
{
  "$schema" : "https://schema.management.azure.com/schemas/2015-01-01/deploymentTemplate.json#",
  "contentVersion" : "1.0.0.0",
  "parameters" : {
    "baseName" : {
      "type" : "string",
      "minLength" : 1,
      "metadata" : {
        "description" : "Base name to be used in resource names (usually the cluster's Infra ID)"
      }
    },
    "vnetBaseName": {
      "type": "string",
      "defaultValue": "",
      "metadata" : {
        "description" : "The specific customer vnet's base name (optional)"
      }
    },
    "masterIgnition" : {
      "type" : "string",
      "metadata" : {
        "description" : "Ignition content for the master nodes"
      }
    },
    "numberOfMasters" : {
      "type" : "int",
      "defaultValue" : 3,
      "minValue" : 2,
      "maxValue" : 30,
      "metadata" : {
        "description" : "Number of OpenShift masters to deploy"
      }
    },
    "sshKeyData" : {
      "type" : "securestring",
      "defaultValue" : "Unused",
      "metadata" : {
        "description" : "Unused"
      }
    },
    "privateDNSZoneName" : {
      "type" : "string",
      "defaultValue" : "",
      "metadata" : {
        "description" : "unused"
      }
    },
    "masterVMSize" : {
      "type" : "string",
      "defaultValue" : "Standard_D8s_v3",
```

```
      "metadata" : {
        "description" : "The size of the Master Virtual Machines"
      }
    },
    "diskSizeGB" : {
      "type" : "int",
      "defaultValue" : 1024,
      "metadata" : {
        "description" : "Size of the Master VM OS disk, in GB"
      }
    }
  },
  "variables" : {
    "location" : "[resourceGroup().location]",
    "virtualNetworkName" : "[concat(if(not(empty(parameters('vnetBaseName'))),
parameters('vnetBaseName'), parameters('baseName')), '-vnet')]",
    "virtualNetworkID" : "[resourceId('Microsoft.Network/virtualNetworks',
variables('virtualNetworkName'))]",
    "masterSubnetName" : "[concat(if(not(empty(parameters('vnetBaseName'))),
parameters('vnetBaseName'), parameters('baseName')), '-master-subnet')]",
    "masterSubnetRef" : "[concat(variables('virtualNetworkID'), '/subnets/',
variables('masterSubnetName'))]",
    "masterLoadBalancerName" : "[concat(parameters('baseName'), '-public-lb')]",
    "internalLoadBalancerName" : "[concat(parameters('baseName'), '-internal-lb')]",
    "sshKeyPath" : "/home/core/.ssh/authorized_keys",
    "identityName" : "[concat(parameters('baseName'), '-identity')]",
    "imageName" : "[concat(parameters('baseName'), '-image')]",
    "copy" : [
      {
        "name" : "vmNames",
        "count" :  "[parameters('numberOfMasters')]",
        "input" : "[concat(parameters('baseName'), '-master-', copyIndex('vmNames'))]"
      }
    ]
  },
  "resources" : [
    {
      "apiVersion" : "2018-06-01",
      "type" : "Microsoft.Network/networkInterfaces",
      "copy" : {
        "name" : "nicCopy",
        "count" : "[length(variables('vmNames'))]"
      },
      "name" : "[concat(variables('vmNames')[copyIndex()], '-nic')]",
      "location" : "[variables('location')]",
      "properties" : {
        "ipConfigurations" : [
          {
            "name" : "pipConfig",
            "properties" : {
              "privateIPAllocationMethod" : "Dynamic",
              "subnet" : {
                "id" : "[variables('masterSubnetRef')]"
              },
              "loadBalancerBackendAddressPools" : [
                {
```

```
                "id" : "[concat('/subscriptions/', subscription().subscriptionId, '/resourceGroups/',
resourceGroup().name, '/providers/Microsoft.Network/loadBalancers/',
variables('masterLoadBalancerName'), '/backendAddressPools/public-lb-backend')]"
              },
              {
                "id" : "[concat('/subscriptions/', subscription().subscriptionId, '/resourceGroups/',
resourceGroup().name, '/providers/Microsoft.Network/loadBalancers/',
variables('internalLoadBalancerName'), '/backendAddressPools/internal-lb-backend')]"
              }
            ]
          }
        }
      ]
    }
  },
  {
    "apiVersion" : "2018-06-01",
    "type" : "Microsoft.Compute/virtualMachines",
    "copy" : {
      "name" : "vmCopy",
      "count" : "[length(variables('vmNames'))]"
    },
    "name" : "[variables('vmNames')[copyIndex()]]",
    "location" : "[variables('location')]",
    "identity" : {
      "type" : "userAssigned",
      "userAssignedIdentities" : {
        "[resourceID('Microsoft.ManagedIdentity/userAssignedIdentities/',
variables('identityName'))]" : {}
      }
    },
    "dependsOn" : [
      "[concat('Microsoft.Network/networkInterfaces/', concat(variables('vmNames')[copyIndex()], '-
nic'))]"
    ],
    "properties" : {
      "hardwareProfile" : {
        "vmSize" : "[parameters('masterVMSize')]"
      },
      "osProfile" : {
        "computerName" : "[variables('vmNames')[copyIndex()]]",
        "adminUsername" : "core",
        "adminPassword" : "NotActuallyApplied!",
        "customData" : "[parameters('masterIgnition')]",
        "linuxConfiguration" : {
          "disablePasswordAuthentication" : false
        }
      },
      "storageProfile" : {
        "imageReference": {
          "id": "[resourceId('Microsoft.Compute/images', variables('imageName'))]"
        },
        "osDisk" : {
          "name": "[concat(variables('vmNames')[copyIndex()], '_OSDisk')]",
          "osType" : "Linux",
          "createOption" : "FromImage",
```

```
            "caching": "ReadOnly",
            "writeAcceleratorEnabled": false,
            "managedDisk": {
              "storageAccountType": "Premium_LRS"
            },
            "diskSizeGB" : "[parameters('diskSizeGB')]"
          }
        },
        "networkProfile" : {
          "networkInterfaces" : [
            {
              "id" : "[resourceId('Microsoft.Network/networkInterfaces', concat(variables('vmNames')
[copyIndex()], '-nic'))]",
              "properties": {
                "primary": false
              }
            }
          ]
        }
      }
    }
  ]
}
```

6.11.18. Wait for bootstrap completion and remove bootstrap resources in Azure

After you create all of the required infrastructure in Microsoft Azure, wait for the bootstrap process to complete on the machines that you provisioned by using the Ignition config files that you generated with the installation program.

Prerequisites

- Configure an Azure account.
- Generate the Ignition config files for your cluster.
- Create and configure a VNet and associated subnets in Azure.
- Create and configure networking and load balancers in Azure.
- Create control plane and compute roles.
- Create the bootstrap machine.
- Create the control plane machines.

Procedure

1. Change to the directory that contains the installation program and run the following command:

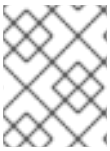
```
$ ./openshift-install wait-for bootstrap-complete --dir <installation_directory> \ 1
    --log-level info 2
```

1. For **<installation_directory>**, specify the path to the directory that you stored the installation files in.
2. To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

If the command exits without a **FATAL** warning, your production control plane has initialized.

2. Delete the bootstrap resources:

```
$ az network nsg rule delete -g ${RESOURCE_GROUP} --nsg-name ${INFRA_ID}-nsg --
name bootstrap_ssh_in
$ az vm stop -g ${RESOURCE_GROUP} --name ${INFRA_ID}-bootstrap
$ az vm deallocate -g ${RESOURCE_GROUP} --name ${INFRA_ID}-bootstrap
$ az vm delete -g ${RESOURCE_GROUP} --name ${INFRA_ID}-bootstrap --yes
$ az disk delete -g ${RESOURCE_GROUP} --name ${INFRA_ID}-bootstrap_OSDisk --no-
wait --yes
$ az network nic delete -g ${RESOURCE_GROUP} --name ${INFRA_ID}-bootstrap-nic --no-
wait
$ az storage blob delete --account-key ${ACCOUNT_KEY} --account-name
${CLUSTER_NAME}sa --container-name files --name bootstrap.ign
$ az network public-ip delete -g ${RESOURCE_GROUP} --name ${INFRA_ID}-bootstrap-
ssh-pip
```



NOTE

If you do not delete the bootstrap server, installation may not succeed due to API traffic being routed to the bootstrap server.

6.11.19. Creating additional worker machines in Azure

You can create worker machines in Microsoft Azure for your cluster to use by launching individual instances discretely or by automated processes outside the cluster, such as auto scaling groups. You can also take advantage of the built-in cluster scaling mechanisms and the machine API in OpenShift Container Platform.

In this example, you manually launch one instance by using the Azure Resource Manager (ARM) template. Additional instances can be launched by including additional resources of type **06_workers.json** in the file.

NOTE

By default, Microsoft Azure places control plane machines and compute machines in a pre-set availability zone. You can manually set an availability zone for a compute node or control plane node. To do this, modify a vendor's ARM template by specifying each of your availability zones in the **zones** parameter of the virtual machine resource.

If you do not use the provided ARM template to create your control plane machines, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, consider contacting Red Hat support with your installation logs.

Prerequisites

- Configure an Azure account.

- Generate the Ignition config files for your cluster.
- Create and configure a VNet and associated subnets in Azure.
- Create and configure networking and load balancers in Azure.
- Create control plane and compute roles.
- Create the bootstrap machine.
- Create the control plane machines.

Procedure

1. Copy the template from the **ARM template for worker machines** section of this topic and save it as **06_workers.json** in your cluster's installation directory. This template describes the worker machines that your cluster requires.
2. Export the following variable needed by the worker machine deployment:

```
$ export WORKER_IGNITION=`cat <installation_directory>/worker.ign | base64 | tr -d '\n'`
```

3. Create the deployment by using the **az** CLI:

```
$ az deployment group create -g ${RESOURCE_GROUP} \
  --template-file "<installation_directory>/06_workers.json" \
  --parameters workerIgnition="${WORKER_IGNITION}" \ 1
  --parameters baseName="${INFRA_ID}" 2
```

1. The Ignition content for the worker nodes.
2. The base name to be used in resource names; this is usually the cluster's infrastructure ID.

6.11.19.1. ARM template for worker machines

You can use the following Azure Resource Manager (ARM) template to deploy the worker machines that you need for your OpenShift Container Platform cluster:

Example 6.12. 06_workers.json ARM template

```
{
  "$schema" : "https://schema.management.azure.com/schemas/2015-01-
01/deploymentTemplate.json#",
  "contentVersion" : "1.0.0.0",
  "parameters" : {
    "baseName" : {
      "type" : "string",
      "minLength" : 1,
      "metadata" : {
        "description" : "Base name to be used in resource names (usually the cluster's Infra ID)"
      }
    },
    "vnetBaseName": {
      "type": "string",
```

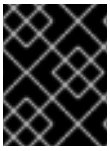
```
      "defaultValue": "",
      "metadata" : {
        "description" : "The specific customer vnet's base name (optional)"
      }
    },
    "workerIgnition" : {
      "type" : "string",
      "metadata" : {
        "description" : "Ignition content for the worker nodes"
      }
    },
    "numberOfNodes" : {
      "type" : "int",
      "defaultValue" : 3,
      "minValue" : 2,
      "maxValue" : 30,
      "metadata" : {
        "description" : "Number of OpenShift compute nodes to deploy"
      }
    },
    "sshKeyData" : {
      "type" : "securestring",
      "defaultValue" : "Unused",
      "metadata" : {
        "description" : "Unused"
      }
    },
    "nodeVMSize" : {
      "type" : "string",
      "defaultValue" : "Standard_D4s_v3",
      "metadata" : {
        "description" : "The size of the each Node Virtual Machine"
      }
    }
  },
  "variables" : {
    "location" : "[resourceGroup().location]",
    "virtualNetworkName" : "[concat(if(not(empty(parameters('vnetBaseName'))),
parameters('vnetBaseName'), parameters('baseName')), '-vnet')]",
    "virtualNetworkID" : "[resourceId('Microsoft.Network/virtualNetworks',
variables('virtualNetworkName'))]",
    "nodeSubnetName" : "[concat(if(not(empty(parameters('vnetBaseName'))),
parameters('vnetBaseName'), parameters('baseName')), '-worker-subnet')]",
    "nodeSubnetRef" : "[concat(variables('virtualNetworkID'), '/subnets/',
variables('nodeSubnetName'))]",
    "infraLoadBalancerName" : "[parameters('baseName')]",
    "sshKeyPath" : "/home/capi/.ssh/authorized_keys",
    "identityName" : "[concat(parameters('baseName'), '-identity')]",
    "imageName" : "[concat(parameters('baseName'), '-image')]",
    "copy" : [
      {
        "name" : "vmNames",
        "count" :  "[parameters('numberOfNodes')]",
        "input" : "[concat(parameters('baseName'), '-worker-', variables('location'), '-',
copyIndex('vmNames', 1))]"
      }
```

```
    ]
  },
  "resources" : [
    {
      "apiVersion" : "2019-05-01",
      "name" : "[concat('node', copyIndex())]",
      "type" : "Microsoft.Resources/deployments",
      "copy" : {
        "name" : "nodeCopy",
        "count" : "[length(variables('vmNames'))]"
      },
      "properties" : {
        "mode" : "Incremental",
        "template" : {
          "$schema" : "http://schema.management.azure.com/schemas/2015-01-
01/deploymentTemplate.json#",
          "contentVersion" : "1.0.0.0",
          "resources" : [
            {
              "apiVersion" : "2018-06-01",
              "type" : "Microsoft.Network/networkInterfaces",
              "name" : "[concat(variables('vmNames')[copyIndex()], '-nic')]",
              "location" : "[variables('location')]",
              "properties" : {
                "ipConfigurations" : [
                  {
                    "name" : "pipConfig",
                    "properties" : {
                      "privateIPAllocationMethod" : "Dynamic",
                      "subnet" : {
                        "id" : "[variables('nodeSubnetRef')]"
                      }
                    }
                  }
                ]
              }
            },
            {
              "apiVersion" : "2018-06-01",
              "type" : "Microsoft.Compute/virtualMachines",
              "name" : "[variables('vmNames')[copyIndex()]]",
              "location" : "[variables('location')]",
              "tags" : {
                "kubernetes.io-cluster-ffranzupi": "owned"
              },
              "identity" : {
                "type" : "userAssigned",
                "userAssignedIdentities" : {
                  "[resourceID('Microsoft.ManagedIdentity/userAssignedIdentities/',
variables('identityName'))]" : {}
                }
              },
              "dependsOn" : [
                "[concat('Microsoft.Network/networkInterfaces/', concat(variables('vmNames')
[copyIndex()], '-nic'))]"
              ],
```

```
            "properties" : {
              "hardwareProfile" : {
                "vmSize" : "[parameters('nodeVMSize')]"
              },
              "osProfile" : {
                "computerName" : "[variables('vmNames')[copyIndex()]]",
                "adminUsername" : "capi",
                "adminPassword" : "NotActuallyApplied!",
                "customData" : "[parameters('workerIgnition')]",
                "linuxConfiguration" : {
                  "disablePasswordAuthentication" : false
                }
              },
              "storageProfile" : {
                "imageReference": {
                  "id": "[resourceId('Microsoft.Compute/images', variables('imageName'))]"
                },
                "osDisk" : {
                  "name": "[concat(variables('vmNames')[copyIndex()],'_OSDisk')]",
                  "osType" : "Linux",
                  "createOption" : "FromImage",
                  "managedDisk": {
                    "storageAccountType": "Premium_LRS"
                  },
                  "diskSizeGB": 128
                }
              },
              "networkProfile" : {
                "networkInterfaces" : [
                  {
                    "id" : "[resourceId('Microsoft.Network/networkInterfaces',
concat(variables('vmNames')[copyIndex()], '-nic'))]",
                    "properties": {
                      "primary": true
                    }
                  }
                ]
              }
            }
          ]
        }
      }
    ]
}
```

6.11.20. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.



IMPORTANT

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.11. Download and install the new version of **oc**.

Installing the OpenShift CLI on Linux

You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the architecture in the **Product Variant** drop-down menu.
3. Select the appropriate version in the **Version** drop-down menu.
4. Click **Download Now** next to the **OpenShift v4.11 Linux Client** entry and save the file.
5. Unpack the archive:

```
$ tar xvf <file>
```

6. Place the **oc** binary in a directory that is on your **PATH**.
   To check your **PATH**, execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.
   To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

Verification

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
C:\> oc <command>
```

Installing the OpenShift CLI on macOS
You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 macOS Client** entry and save the file.

NOTE

For macOS arm64, choose the **OpenShift v4.11 macOS arm64 Client** entry.

4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your PATH.
To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

6.11.21. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

Example output

```
system:admin
```

6.11.22. Approving the certificate signing requests for your machines

When you add machines to a cluster, two pending certificate signing requests (CSRs) are generated for each machine that you added. You must confirm that these CSRs are approved or, if necessary, approve them yourself. The client requests must be approved first, followed by the server requests.

Prerequisites

- You added machines to your cluster.

Procedure

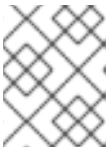
1. Confirm that the cluster recognizes the machines:

```
$ oc get nodes
```

Example output

```
NAME      STATUS    ROLES   AGE  VERSION
master-0  Ready     master  63m  v1.24.0
master-1  Ready     master  63m  v1.24.0
master-2  Ready     master  64m  v1.24.0
```

The output lists all of the machines that you created.



NOTE

The preceding output might not include the compute nodes, also known as worker nodes, until some CSRs are approved.

2. Review the pending CSRs and ensure that you see the client requests with the **Pending** or **Approved** status for each machine that you added to the cluster:

```
$ oc get csr
```

Example output

```
NAME        AGE     REQUESTOR                                                   CONDITION
csr-8b2br   15m     system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper   Pending
```

```
csr-8vnps   15m     system:serviceaccount:openshift-machine-config-operator:node-bootstrapper   Pending
...
```

In this example, two machines are joining the cluster. You might see more approved CSRs in the list.

3. If the CSRs were not approved, after all of the pending CSRs for the machines you added are in **Pending** status, approve the CSRs for your cluster machines:

NOTE

Because the CSRs rotate automatically, approve your CSRs within an hour of adding the machines to the cluster. If you do not approve them within an hour, the certificates will rotate, and more than two certificates will be present for each node. You must approve all of these certificates. After the client CSR is approved, the Kubelet creates a secondary CSR for the serving certificate, which requires manual approval. Then, subsequent serving certificate renewal requests are automatically approved by the **machine-approver** if the Kubelet requests a new certificate with identical parameters.

NOTE

For clusters running on platforms that are not machine API enabled, such as bare metal and other user-provisioned infrastructure, you must implement a method of automatically approving the kubelet serving certificate requests (CSRs). If a request is not approved, then the **oc exec**, **oc rsh**, and **oc logs** commands cannot succeed, because a serving certificate is required when the API server connects to the kubelet. Any operation that contacts the Kubelet endpoint requires this certificate approval to be in place. The method must watch for new CSRs, confirm that the CSR was submitted by the **node-bootstrapper** service account in the **system:node** or **system:admin** groups, and confirm the identity of the node.

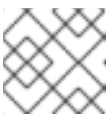
- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

1 **<csr_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{{"\n"}}{{end}}{{end}}' | xargs --no-run-if-empty oc adm certificate approve
```



NOTE

Some Operators might not become available until some CSRs are approved.

4. Now that your client requests are approved, you must review the server requests for each machine that you added to the cluster:

```
$ oc get csr
```

Example output

```
NAME        AGE     REQUESTOR                                                   CONDITION
csr-bfd72   5m26s   system:node:ip-10-0-50-126.us-east-2.compute.internal
Pending
csr-c57lv   5m26s   system:node:ip-10-0-95-157.us-east-2.compute.internal
Pending
...
```

5. If the remaining CSRs are not approved, and are in the **Pending** status, approve the CSRs for your cluster machines:

   - To approve them individually, run the following command for each valid CSR:

     ```
     $ oc adm certificate approve <csr_name> 1
     ```

     1 **<csr_name>** is the name of a CSR from the list of current CSRs.

   - To approve all pending CSRs, run the following command:

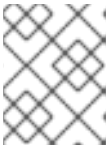
     ```
     $ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{{"\n"}}
     {{end}}{{end}}' | xargs oc adm certificate approve
     ```

6. After all client and server CSRs have been approved, the machines have the **Ready** status. Verify this by running the following command:

   ```
   $ oc get nodes
   ```

   Example output

   ```
   NAME      STATUS    ROLES   AGE  VERSION
   master-0  Ready     master  73m  v1.24.0
   master-1  Ready     master  73m  v1.24.0
   master-2  Ready     master  74m  v1.24.0
   worker-0  Ready     worker  11m  v1.24.0
   worker-1  Ready     worker  11m  v1.24.0
   ```



NOTE

It can take a few minutes after approval of the server CSRs for the machines to transition to the **Ready** status.

Additional information

- For more information on CSRs, see Certificate Signing Requests.

6.11.23. Adding the Ingress DNS records

If you removed the DNS Zone configuration when creating Kubernetes manifests and generating

Ignition configs, you must manually create DNS records that point at the Ingress load balancer. You can create either a wildcard ***.apps.{baseDomain}.** or specific records. You can use A, CNAME, and other records per your requirements.

Prerequisites

- You deployed an OpenShift Container Platform cluster on Microsoft Azure by using infrastructure that you provisioned.
- Install the OpenShift CLI (**oc**).
- Install or update the Azure CLI.

Procedure

1. Confirm the Ingress router has created a load balancer and populated the **EXTERNAL-IP** field:

```
$ oc -n openshift-ingress get service router-default
```

Example output

```
NAME            TYPE           CLUSTER-IP     EXTERNAL-IP     PORT(S)                      AGE
router-default  LoadBalancer   172.30.20.10   35.130.120.110
80:32288/TCP,443:31215/TCP   20
```

2. Export the Ingress router IP as a variable:

```
$ export PUBLIC_IP_ROUTER=`oc -n openshift-ingress get service router-default --no-
headers | awk '{print $4}'`
```

3. Add a ***.apps** record to the public DNS zone.

   a. If you are adding this cluster to a new public zone, run:

```
$ az network dns record-set a add-record -g ${BASE_DOMAIN_RESOURCE_GROUP} -
z ${CLUSTER_NAME}.${BASE_DOMAIN} -n *.apps -a ${PUBLIC_IP_ROUTER} --ttl 300
```

   b. If you are adding this cluster to an already existing public zone, run:

```
$ az network dns record-set a add-record -g ${BASE_DOMAIN_RESOURCE_GROUP} -
z ${BASE_DOMAIN} -n *.apps.${CLUSTER_NAME} -a ${PUBLIC_IP_ROUTER} --ttl 300
```

4. Add a ***.apps** record to the private DNS zone:

   a. Create a ***.apps** record by using the following command:

```
$ az network private-dns record-set a create -g ${RESOURCE_GROUP} -z
${CLUSTER_NAME}.${BASE_DOMAIN} -n *.apps --ttl 300
```

   b. Add the ***.apps** record to the private DNS zone by using the following command:

```
$ az network private-dns record-set a add-record -g ${RESOURCE_GROUP} -z
${CLUSTER_NAME}.${BASE_DOMAIN} -n *.apps -a ${PUBLIC_IP_ROUTER}
```

If you prefer to add explicit domains instead of using a wildcard, you can create entries for each of the cluster's current routes:

```
$ oc get --all-namespaces -o jsonpath='{range .items[*]}{range .status.ingress[*]}{.host}{"\n"}{end}{end}' routes
```

Example output

```
oauth-openshift.apps.cluster.basedomain.com
console-openshift-console.apps.cluster.basedomain.com
downloads-openshift-console.apps.cluster.basedomain.com
alertmanager-main-openshift-monitoring.apps.cluster.basedomain.com
prometheus-k8s-openshift-monitoring.apps.cluster.basedomain.com
```

6.11.24. Completing an Azure installation on user-provisioned infrastructure

After you start the OpenShift Container Platform installation on Microsoft Azure user-provisioned infrastructure, you can monitor the cluster events until the cluster is ready.

Prerequisites

- Deploy the bootstrap machine for an OpenShift Container Platform cluster on user-provisioned Azure infrastructure.
- Install the **oc** CLI and log in.

Procedure

- Complete the cluster installation:

```
$ ./openshift-install --dir <installation_directory> wait-for install-complete 1
```

Example output

```
INFO Waiting up to 30m0s for the cluster to initialize...
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

6.11.25. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.11, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to OpenShift Cluster Manager Hybrid Cloud Console.

After you confirm that your OpenShift Cluster Manager Hybrid Cloud Console inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, use subscription watch to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

Additional resources

- See About remote health monitoring for more information about the Telemetry service

6.12. UNINSTALLING A CLUSTER ON AZURE

You can remove a cluster that you deployed to Microsoft Azure.

6.12.1. Removing a cluster that uses installer-provisioned infrastructure

You can remove a cluster that uses installer-provisioned infrastructure from your cloud.

NOTE

After uninstallation, check your cloud provider for any resources not removed properly, especially with User Provisioned Infrastructure (UPI) clusters. There might be resources that the installer did not create or that the installer is unable to access.

Prerequisites

- You have a copy of the installation program that you used to deploy the cluster.
- You have the files that the installation program generated when you created your cluster.

While you can uninstall the cluster using the copy of the installation program that was used to deploy it, using OpenShift Container Platform version 4.13 or later is recommended.

The removal of service principals is dependent on the Microsoft Azure AD Graph API. Using version 4.13 or later of the installation program ensures that service principals are removed without the need for manual intervention, if and when Microsoft decides to retire the Azure AD Graph API.

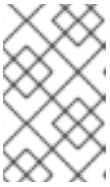
Procedure

1. On the computer that you used to install the cluster, go to the directory that contains the installation program, and run the following command:

```
$ ./openshift-install destroy cluster \
--dir <installation_directory> --log-level info 1 2
```

1. For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2. To view different details, specify **warn**, **debug**, or **error** instead of **info**.



NOTE

You must specify the directory that contains the cluster definition files for your cluster. The installation program requires the **metadata.json** file in this directory to delete the cluster.

2. Optional: Delete the **<installation_directory>** directory and the OpenShift Container Platform installation program.

CHAPTER 7. INSTALLING ON AZURE STACK HUB

7.1. PREPARING TO INSTALL ON AZURE STACK HUB

7.1.1. Prerequisites

- You reviewed details about the OpenShift Container Platform installation and update processes.
- You read the documentation on selecting a cluster installation method and preparing it for users.
- You have installed Azure Stack Hub version 2008 or later.

7.1.2. Requirements for installing OpenShift Container Platform on Azure Stack Hub

Before installing OpenShift Container Platform on Microsoft Azure Stack Hub, you must configure an Azure account.

See Configuring an Azure Stack Hub account for details about account configuration, account limits, DNS zone configuration, required roles, and creating service principals.

7.1.3. Choosing a method to install OpenShift Container Platform on Azure Stack Hub

You can install OpenShift Container Platform on installer-provisioned or user-provisioned infrastructure. The default installation type uses installer-provisioned infrastructure, where the installation program provisions the underlying infrastructure for the cluster. You can also install OpenShift Container Platform on infrastructure that you provision. If you do not use infrastructure that the installation program provisions, you must manage and maintain the cluster resources yourself.

See Installation process for more information about installer-provisioned and user-provisioned installation processes.

7.1.3.1. Installing a cluster on installer-provisioned infrastructure

You can install a cluster on Azure Stack Hub infrastructure that is provisioned by the OpenShift Container Platform installation program, by using the following method:

- **Installing a cluster on Azure Stack Hub with an installer-provisioned infrastructure** You can install OpenShift Container Platform on Azure Stack Hub infrastructure that is provisioned by the OpenShift Container Platform installation program.

7.1.3.2. Installing a cluster on user-provisioned infrastructure

You can install a cluster on Azure Stack Hub infrastructure that you provision, by using the following method:

- **Installing a cluster on Azure Stack Hub using ARM templates** You can install OpenShift Container Platform on Azure Stack Hub by using infrastructure that you provide. You can use the provided Azure Resource Manager (ARM) templates to assist with an installation.

7.1.4. Next steps

- Configuring an Azure Stack Hub account

7.2. CONFIGURING AN AZURE STACK HUB ACCOUNT

Before you can install OpenShift Container Platform, you must configure a Microsoft Azure account.

IMPORTANT

All Azure resources that are available through public endpoints are subject to resource name restrictions, and you cannot create resources that use certain terms. For a list of terms that Azure restricts, see Resolve reserved resource name errors in the Azure documentation.

7.2.1. Azure Stack Hub account limits

The OpenShift Container Platform cluster uses a number of Microsoft Azure Stack Hub components, and the default Quota types in Azure Stack Hub affect your ability to install OpenShift Container Platform clusters.

The following table summarizes the Azure Stack Hub components whose limits can impact your ability to install and run OpenShift Container Platform clusters.

Component	Number of components required by default	Description
vCPU	56	A default cluster requires 56 vCPUs, so you must increase the account limit. By default, each cluster creates the following instances: • One bootstrap machine, which is removed after installation • Three control plane machines • Three compute machines Because the bootstrap, control plane, and worker machines use **Standard_DS4_v2** virtual machines, which use 8 vCPUs, a default cluster requires 56 vCPUs. The bootstrap node VM is used only during installation. To deploy more worker nodes, enable autoscaling, deploy large workloads, or use a different instance type, you must further increase the vCPU limit for your account to ensure that your cluster can deploy the machines that you require.
VNet	1	Each default cluster requires one Virtual Network (VNet), which contains two subnets.
Network interfaces	7	Each default cluster requires seven network interfaces. If you create more machines or your deployed workloads create load balancers, your cluster uses more network interfaces.

<table>
<tr><th>Component</th><th>Number of components required by default</th><th>Description</th></tr>
<tr><td>Network security groups</td><td>2</td><td>Each cluster creates network security groups for each subnet in the VNet. The default cluster creates network security groups for the control plane and for the compute node subnets:<table><tr><td>controlplane</td><td>Allows the control plane machines to be reached on port 6443 from anywhere</td></tr><tr><td>node</td><td>Allows worker nodes to be reached from the internet on ports 80 and 443</td></tr></table></td></tr>
<tr><td>Network load balancers</td><td>3</td><td>Each cluster creates the following load balancers:<table><tr><td>default</td><td>Public IP address that load balances requests to ports 80 and 443 across worker machines</td></tr><tr><td>internal</td><td>Private IP address that load balances requests to ports 6443 and 22623 across control plane machines</td></tr><tr><td>external</td><td>Public IP address that load balances requests to port 6443 across control plane machines</td></tr></table>If your applications create more Kubernetes LoadBalancer service objects, your cluster uses more load balancers.</td></tr>
<tr><td>Public IP addresses</td><td>2</td><td>The public load balancer uses a public IP address. The bootstrap machine also uses a public IP address so that you can SSH into the machine to troubleshoot issues during installation. The IP address for the bootstrap node is used only during installation.</td></tr>
<tr><td>Private IP addresses</td><td>7</td><td>The internal load balancer, each of the three control plane machines, and each of the three worker machines each use a private IP address.</td></tr>
</table>

Additional resources

- Optimizing storage.

7.2.2. Configuring a DNS zone in Azure Stack Hub

To successfully install OpenShift Container Platform on Azure Stack Hub, you must create DNS records in an Azure Stack Hub DNS zone. The DNS zone must be authoritative for the domain. To delegate a registrar's DNS zone to Azure Stack Hub, see Microsoft's documentation for Azure Stack Hub datacenter DNS integration.

7.2.3. Required Azure Stack Hub roles

Your Microsoft Azure Stack Hub account must have the following roles for the subscription that you use:

- **Owner**

To set roles on the Azure portal, see the Manage access to resources in Azure Stack Hub with role-based access control in the Microsoft documentation.

7.2.4. Creating a service principal

Because OpenShift Container Platform and its installation program create Microsoft Azure resources by using the Azure Resource Manager, you must create a service principal to represent it.

Prerequisites

- Install or update the Azure CLI.
- Your Azure account has the required roles for the subscription that you use.

Procedure

1. Register your environment:

```
$ az cloud register -n AzureStackCloud --endpoint-resource-manager <endpoint> 1
```

1 Specify the Azure Resource Manager endpoint, `https://management.<region>.<fqdn>/`.

   See the Microsoft documentation for details.

2. Set the active environment:

```
$ az cloud set -n AzureStackCloud
```

3. Update your environment configuration to use the specific API version for Azure Stack Hub:

```
$ az cloud update --profile 2019-03-01-hybrid
```

4. Log in to the Azure CLI:

```
$ az login
```

   If you are in a multitenant environment, you must also supply the tenant ID.

5. If your Azure account uses subscriptions, ensure that you are using the right subscription:

   a. View the list of available accounts and record the **tenantId** value for the subscription you want to use for your cluster:

```
$ az account list --refresh
```

   Example output

```
[
  {
    "cloudName": AzureStackCloud",
    "id": "9bab1460-96d5-40b3-a78e-17b15e978a80",
    "isDefault": true,
    "name": "Subscription Name",
    "state": "Enabled",
    "tenantId": "6057c7e9-b3ae-489d-a54e-de3f6bf6a8ee",
    "user": {
      "name": "you@example.com",
      "type": "user"
    }
  }
]
```

b. View your active account details and confirm that the **tenantId** value matches the subscription you want to use:

```
$ az account show
```

Example output

```
{
  "environmentName": AzureStackCloud",
  "id": "9bab1460-96d5-40b3-a78e-17b15e978a80",
  "isDefault": true,
  "name": "Subscription Name",
  "state": "Enabled",
  "tenantId": "6057c7e9-b3ae-489d-a54e-de3f6bf6a8ee", (1)
  "user": {
    "name": "you@example.com",
    "type": "user"
  }
}
```

(1) Ensure that the value of the **tenantId** parameter is the correct subscription ID.

c. If you are not using the right subscription, change the active subscription:

```
$ az account set -s <subscription_id> (1)
```

(1) Specify the subscription ID.

d. Verify the subscription ID update:

```
$ az account show
```

Example output

```
{
  "environmentName": AzureStackCloud",
```

```
  "id": "33212d16-bdf6-45cb-b038-f6565b61edda",
  "isDefault": true,
  "name": "Subscription Name",
  "state": "Enabled",
  "tenantId": "8049c7e9-c3de-762d-a54e-dc3f6be6a7ee",
  "user": {
    "name": "you@example.com",
    "type": "user"
  }
}
```

6. Record the **tenantId** and **id** parameter values from the output. You need these values during the OpenShift Container Platform installation.

7. Create the service principal for your account:

```
$ az ad sp create-for-rbac --role Contributor --name <service_principal> \ 1
  --scopes /subscriptions/<subscription_id> 2
  --years <years> 3
```

1. Specify the service principal name.
2. Specify the subscription ID.
3. Specify the number of years. By default, a service principal expires in one year. By using the **--years** option you can extend the validity of your service principal.

Example output

```
Creating 'Contributor' role assignment under scope '/subscriptions/<subscription_id>'
The output includes credentials that you must protect. Be sure that you do not
include these credentials in your code or check the credentials into your source
control. For more information, see https://aka.ms/azadsp-cli
{
  "appId": "ac461d78-bf4b-4387-ad16-7e32e328aec6",
  "displayName": <service_principal>",
  "password": "00000000-0000-0000-0000-000000000000",
  "tenantId": "8049c7e9-c3de-762d-a54e-dc3f6be6a7ee"
}
```

8. Record the values of the **appId** and **password** parameters from the previous output. You need these values during OpenShift Container Platform installation.

Additional resources

- For more information about CCO modes, see About the Cloud Credential Operator.

7.2.5. Next steps

- Install an OpenShift Container Platform cluster:
  - Installing a cluster quickly on Azure Stack Hub .

- Install an OpenShift Container Platform cluster on Azure Stack Hub with user-provisioned infrastructure by following Installing a cluster on Azure Stack Hub using ARM templates .

7.3. INSTALLING A CLUSTER ON AZURE STACK HUB WITH AN INSTALLER-PROVISIONED INFRASTRUCTURE

In OpenShift Container Platform version 4.11, you can install a cluster on Microsoft Azure Stack Hub with an installer-provisioned infrastructure. However, you must manually configure the **install-config.yaml** file to specify values that are specific to Azure Stack Hub.

NOTE

While you can select **azure** when using the installation program to deploy a cluster using installer-provisioned infrastructure, this option is only supported for the Azure Public Cloud.

7.3.1. Prerequisites

- You reviewed details about the OpenShift Container Platform installation and update processes.
- You read the documentation on selecting a cluster installation method and preparing it for users.
- You configured an Azure Stack Hub account to host the cluster.
- If you use a firewall, you configured it to allow the sites that your cluster requires access to.
- You verified that you have approximately 16 GB of local disk space. Installing the cluster requires that you download the RHCOS virtual hard disk (VHD) cluster image and upload it to your Azure Stack Hub environment so that it is accessible during deployment. Decompressing the VHD files requires this amount of local disk space.

7.3.2. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.11, you require access to the internet to install your cluster.

You must have internet access to:

- Access OpenShift Cluster Manager Hybrid Cloud Console to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access Quay.io to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.

IMPORTANT

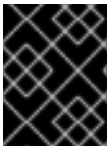
If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

7.3.3. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the **~/.ssh/authorized_keys** list for the **core** user on each node, which enables password-less authentication.

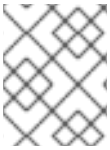
After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The **./openshift-install gather** command also requires the SSH public key to be in place on the cluster nodes.



IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.



NOTE

You must use a local key, not one that you configured with platform-specific approaches such as AWS key pairs.

Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N '' -f <path>/<file_name> 1
```

1 Specify the path and file name, such as **~/.ssh/id_ed25519**, of the new SSH key. If you have an existing key pair, ensure your public key is in the your **~/.ssh** directory.

NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS validated or Modules In Process cryptographic libraries on the **x86_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the **~/.ssh/id_ed25519.pub** public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the **./openshift-install gather** command.

NOTE

On some distributions, default SSH private key identities such as **~/.ssh/id_rsa** and **~/.ssh/id_dsa** are managed automatically.

   a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

Example output

```
Agent pid 31874
```

NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

1 Specify the path and file name for your SSH private key, such as **~/.ssh/id_ed25519**

Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

7.3.4. Uploading the RHCOS cluster image

You must download the RHCOS virtual hard disk (VHD) cluster image and upload it to your Azure Stack Hub environment so that it is accessible during deployment.

Prerequisites

- Configure an Azure account.

Procedure

1. Obtain the RHCOS VHD cluster image:

a. Export the URL of the RHCOS VHD to an environment variable.

```
$ export COMPRESSED_VHD_URL=$(openshift-install coreos print-stream-json | jq -r
'.architectures.x86_64.artifacts.azurestack.formats."vhd.gz".disk.location')
```

b. Download the compressed RHCOS VHD file locally.

```
$ curl -O -L ${COMPRESSED_VHD_URL}
```

2. Decompress the VHD file.

NOTE

The decompressed VHD file is approximately 16 GB, so be sure that your host system has 16 GB of free space available. The VHD file can be deleted once you have uploaded it.

3. Upload the local VHD to the Azure Stack Hub environment, making sure that the blob is publicly available. For example, you can upload the VHD to a blob using the **az** cli or the web portal.

7.3.5. Obtaining the installation program

Before you install OpenShift Container Platform, download the installation file on a local computer.

Prerequisites

- You have a computer that runs Linux or macOS, with 500 MB of local disk space.

Procedure

1. Access the Infrastructure Provider page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select **Azure** as the cloud provider.
3. Navigate to the page for your installation type, download the installation program that corresponds with your host operating system and architecture, and place the file in the directory where you will store the installation configuration files.

IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.

IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation pull secret from the Red Hat OpenShift Cluster Manager . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

7.3.6. Manually creating the installation configuration file

When installing OpenShift Container Platform on Microsoft Azure Stack Hub, you must manually create your installation configuration file.

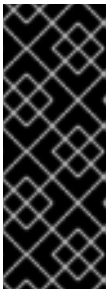
Prerequisites

- You have an SSH public key on your local machine to provide to the installation program. The key will be used for SSH authentication onto your cluster nodes for debugging and disaster recovery.
- You have obtained the OpenShift Container Platform installation program and the pull secret for your cluster.

Procedure

1. Create an installation directory to store your required installation assets in:

```
$ mkdir <installation_directory>
```



IMPORTANT

You must create a directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

2. Customize the sample **install-config.yaml** file template that is provided and save it in the **<installation_directory>**.

NOTE

You must name this configuration file **install-config.yaml**.

Make the following modifications:

a. Specify the required installation parameters.

b. Update the **platform.azure** section to specify the parameters that are specific to Azure Stack Hub.

c. Optional: Update one or more of the default configuration parameters to customize the installation.
For more information about the parameters, see "Installation configuration parameters".

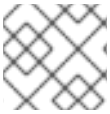
3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.

IMPORTANT

The **install-config.yaml** file is consumed during the next step of the installation process. You must back it up now.

7.3.6.1. Installation configuration parameters

Before you deploy an OpenShift Container Platform cluster, you provide a customized **install-config.yaml** installation configuration file that describes the details for your environment.



NOTE

After installation, you cannot modify these parameters in the **install-config.yaml** file.

7.3.6.1.1. Required configuration parameters

Required installation configuration parameters are described in the following table:

Table 7.1. Required parameters

Parameter	Description	Values
apiVersion	The API version for the **install-config.yaml** content. The current version is **v1**. The installer may also support older API versions.	String
baseDomain	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the **baseDomain** and **metadata.name** parameter values that uses the **<metadata.name>.<baseDomain>** format.	A fully-qualified domain or subdomain name, such as **example.com**.
metadata	Kubernetes resource **ObjectMeta**, from which only the **name** parameter is consumed.	Object

Parameter	Description	Values
metadata.name	The name of the cluster. DNS records for the cluster are all subdomains of **{{.metadata.name}}.{{.baseDomain}}**.	String of lowercase letters, hyphens (**-**), and periods (**.**), such as **dev**.
platform	The configuration for the specific platform upon which to perform the installation: **alibabacloud**, **aws**, **baremetal**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**. For additional information about **platform.<platform>** parameters, consult the table for your specific platform that follows.	Object
pullSecret	Get a pull secret from the Red Hat OpenShift Cluster Manager to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	`{ "auths":{ "cloud.openshift.com":{ "auth":"b3Blb=", "email":"you@example.com" }, "quay.io":{ "auth":"b3Blb=", "email":"you@example.com" } } }`

7.3.6.1.2. Network configuration parameters

You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

Only IPv4 addresses are supported.

NOTE

Globalnet is not supported with Red Hat OpenShift Data Foundation disaster recovery solutions. For regional disaster recovery scenarios, ensure that you use a nonoverlapping range of private IP addresses for the cluster and service networks in each cluster.

Table 7.2. Network parameters

Parameter	Description	Values
networking	The configuration for the cluster network.  **NOTE** You cannot modify parameters specified by the **networking** object after installation.	Object
networking.networkType	The cluster network provider Container Network Interface (CNI) cluster network provider to install.	Either **OpenShiftSDN** or **OVNKubernetes**. **OpenShiftSDN** is a CNI provider for all-Linux networks. **OVNKubernetes** is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is **OpenShiftSDN**.
networking.clusterNetwork	The IP address blocks for pods. The default value is **10.128.0.0/14** with a host prefix of **/23**. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: `networking:` `  clusterNetwork:` `  - cidr: 10.128.0.0/14` `    hostPrefix: 23`
networking.clusterNetwork.cidr	Required if you use **networking.clusterNetwork**. An IP address block. An IPv4 network.	An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between **0** and **32**.
networking.clusterNetwork.hostPrefix	The subnet prefix length to assign to each individual node. For example, if **hostPrefix** is set to **23** then each node is assigned a **/23** subnet out of the given **cidr**. A **hostPrefix** value of **23** provides 510 (2^(32 - 23) - 2) pod IP addresses.	A subnet prefix. The default value is **23**.
networking.serviceNetwork	The IP address block for services. The default value is **172.30.0.0/16**. The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.	An array with an IP address block in CIDR format. For example: `networking:` `  serviceNetwork:` `  - 172.30.0.0/16`

Parameter	Description	Values
networking.machineNetwork	The IP address blocks for machines. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: networking: machineNetwork: - cidr: 10.0.0.0/16
networking.machineNetwork.cidr	Required if you use **networking.machineNetwork**. An IP address block. The default value is **10.0.0.0/16** for all platforms other than libvirt. For libvirt, the default value is **192.168.126.0/24**.	An IP network block in CIDR notation. For example, **10.0.0.0/16**. **NOTE** Set the **networking.machineNetwork** to match the CIDR that the preferred NIC resides in.

7.3.6.1.3. Optional configuration parameters

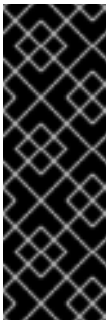
Optional installation configuration parameters are described in the following table:

Table 7.3. Optional parameters

Parameter	Description	Values
additionalTrustBundle	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String
capabilities	Controls the installation of optional core cluster components. You can reduce the footprint of your OpenShift Container Platform cluster by disabling optional components.	String array

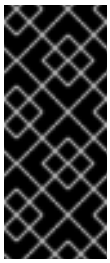
Parameter	Description	Values
capabilities.baselineCapabilitySet	Selects an initial set of optional capabilities to enable. Valid values are **None**, **v4.11** and **vCurrent**. **v4.11** enables the **baremetal** Operator, the **marketplace** Operator, and the **openshift-samples** content. **vCurrent** installs the recommended set of capabilities for the current version of OpenShift Container Platform. The default value is **vCurrent**.	String
capabilities.additionalEnabledCapabilities	Extends the set of optional capabilities beyond what you specify in **baselineCapabilitySet**. Valid values are **baremetal**, **marketplace** and **openshift-samples**. You may specify multiple capabilities in this parameter.	String array
cgroupsV2	Enables Linux control groups version 2 (cgroups v2) on specific nodes in your cluster. The OpenShift Container Platform process for enabling cgroups v2 disables all cgroup version 1 controllers and hierarchies. The OpenShift Container Platform cgroups version 2 feature is in Developer Preview and is not supported by Red Hat at this time.	**true**
compute	The configuration for the machines that comprise the compute nodes.	Array of **MachinePool** objects.
compute.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** (the default).	String

Parameter	Description	Values
compute.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  **IMPORTANT** If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
compute.name	Required if you use **compute**. The name of the machine pool.	**worker**
compute.platform	Required if you use **compute**. Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the **controlPlane.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
compute.replicas	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to **2**. The default value is **3**.
controlPlane	The configuration for the machines that comprise the control plane.	Array of **MachinePool** objects.
controlPlane.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** (the default).	String

Parameter	Description	Values
controlPlane.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  **IMPORTANT** If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
controlPlane.name	Required if you use **controlPlane**. The name of the machine pool.	**master**
controlPlane.platform	Required if you use **controlPlane**. Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the **compute.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
controlPlane.replicas	The number of control plane machines to provision.	The only supported value is **3**, which is the default value.

Parameter	Description	Values
credentialsMode	The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported.  **NOTE** Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the *Cloud Credential Operator* entry in the *Cluster Operators reference* content.  **NOTE** If your AWS account has service control policies (SCP) enabled, you must configure the **credentialsMode** parameter to **Mint**, **Passthrough** or **Manual**.	**Mint**, **Passthrough**, **Manual** or an empty string (**""**).

Parameter	Description	Values
fips	Enable or disable FIPS mode. The default is **false** (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.  **IMPORTANT** To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.  **NOTE** If you are using Azure File storage, you cannot enable FIPS mode.	**false** or **true**

Parameter	Description	Values
imageContentSources	Sources and repositories for the release-image content.	Array of objects. Includes a **source** and, optionally, **mirrors**, as described in the following rows of this table.
imageContentSources.source	Required if you use **imageContentSources**. Specify the repository that users refer to, for example, in image pull specifications.	String
imageContentSources.mirrors	Specify one or more repositories that may also contain the same images.	Array of strings
publish	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	**Internal** or **External**. The default value is **External**. Setting this field to **Internal** is not supported on non-cloud platforms and IBM Cloud VPC.  **IMPORTANT** If the value of the field is set to **Internal**, the cluster will become non-functional. For more information, refer to BZ#1953035.
sshKey	The SSH key to authenticate access to your cluster machines.  **NOTE** For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.	For example, **sshKey: ssh-ed25519 AAAA..**.

7.3.6.1.4. Additional Azure Stack Hub configuration parameters

Additional Azure configuration parameters are described in the following table:

Table 7.4. Additional Azure Stack Hub parameters

Parameter	Description	Values
compute.platform.azure.osDisk.diskSizeGB	The Azure disk size for the VM.	Integer that represents the size of the disk in GB. The default is **128**.
compute.platform.azure.osDisk.diskType	Defines the type of disk.	**standard_LRS** or **premium_LRS**. The default is **premium_LRS**.
compute.platform.azure.type	Defines the azure instance type for compute machines.	String
controlPlane.platform.azure.osDisk.diskSizeGB	The Azure disk size for the VM.	Integer that represents the size of the disk in GB. The default is **1024**.
controlPlane.platform.azure.osDisk.diskType	Defines the type of disk.	**premium_LRS**.
controlPlane.platform.azure.type	Defines the azure instance type for control plane machines.	String
platform.azure.defaultMachinePlatform.osDisk.diskSizeGB	The Azure disk size for the VM.	Integer that represents the size of the disk in GB. The default is **128**.
platform.azure.defaultMachinePlatform.osDisk.diskType	Defines the type of disk.	**standard_LRS** or **premium_LRS**. The default is **premium_LRS**.
platform.azure.defaultMachinePlatform.type	The Azure instance type for control plane and compute machines.	The Azure instance type.
platform.azure.armEndpoint	The URL of the Azure Resource Manager endpoint that your Azure Stack Hub operator provides.	String
platform.azure.baseDomainResourceGroupName	The name of the resource group that contains the DNS zone for your base domain.	String, for example **production_cluster**.
platform.azure.region	The name of your Azure Stack Hub local region.	String

Parameter	Description	Values
platform.azure.resourceGroupName	The name of an already existing resource group to install your cluster to. This resource group must be empty and only used for this specific cluster; the cluster components assume ownership of all resources in the resource group. If you limit the service principal scope of the installation program to this resource group, you must ensure all other resources used by the installation program in your environment have the necessary permissions, such as the public DNS zone and virtual network. Destroying the cluster by using the installation program deletes this resource group.	String, for example **existing_resource_group**.
platform.azure.outboundType	The outbound routing strategy used to connect your cluster to the internet. If you are using user-defined routing, you must have pre-existing networking available where the outbound routing has already been configured prior to installing a cluster. The installation program is not responsible for configuring user-defined routing.	**LoadBalancer** or **UserDefinedRouting**. The default is **LoadBalancer**.
platform.azure.cloudName	The name of the Azure cloud environment that is used to configure the Azure SDK with the appropriate Azure API endpoints.	**AzureStackCloud**
clusterOSImage	The URL of a storage blob in the Azure Stack environment that contains an RHCOS VHD.	String, for example, https://vhdsa.blob.example.example.com/vhd/rhcos-410.84.202112040202-0-azurestack.x86_64.vhd

7.3.6.2. Sample customized install-config.yaml file for Azure Stack Hub

You can customize the **install-config.yaml** file to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.

IMPORTANT

This sample YAML file is provided for reference only. Use it as a resource to enter parameter values into the installation configuration file that you created manually.

```
apiVersion: v1
```

```
baseDomain: example.com (1)
credentialsMode: Manual
controlPlane: (2) (3)
  name: master
  platform:
    azure:
      osDisk:
        diskSizeGB: 1024 (4)
        diskType: premium_LRS
  replicas: 3
compute: (5)
- name: worker
  platform:
    azure:
      osDisk:
        diskSizeGB: 512 (6)
        diskType: premium_LRS
  replicas: 3
metadata:
  name: test-cluster (7) (8)
networking:
  clusterNetwork:
  - cidr: 10.128.0.0/14
    hostPrefix: 23
  machineNetwork:
  - cidr: 10.0.0.0/16
  networkType: OpenShiftSDN
  serviceNetwork:
  - 172.30.0.0/16
platform:
  azure:
    armEndpoint: azurestack_arm_endpoint (9) (10)
    baseDomainResourceGroupName: resource_group (11) (12)
    region: azure_stack_local_region (13) (14)
    resourceGroupName: existing_resource_group (15)
    outboundType: Loadbalancer
    cloudName: AzureStackCloud (16)
    clusterOSimage: https://vhdsa.blob.example.example.com/vhd/rhcos-410.84.202112040202-0-
azurestack.x86_64.vhd (17) (18)
pullSecret: '{"auths": ...}' (19) (20)
fips: false (21)
sshKey: ssh-ed25519 AAAA... (22)
additionalTrustBundle: | (23)
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
```

(1) (7) (9) (11) (13) (16) (17) (19) Required.

(2) (5) If you do not provide these parameters and values, the installation program provides the default value.

(3) The **controlPlane** section is a single mapping, but the **compute** section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section

must begin with a hyphen, **-**, and the first line of the **controlPlane** section must not. Although both sections currently define a single machine pool, it is possible that future versions of OpenShift Container Platform will support defining multiple compute pools during installation. Only one control plane pool is used.

4 6 You can specify the size of the disk to use in GB. Minimum recommendation for control plane nodes is 1024 GB.

8 The name of the cluster.

10 The Azure Resource Manager endpoint that your Azure Stack Hub operator provides.

12 The name of the resource group that contains the DNS zone for your base domain.

14 The name of your Azure Stack Hub local region.

15 The name of an existing resource group to install your cluster to. If undefined, a new resource group is created for the cluster.

18 The URL of a storage blob in the Azure Stack environment that contains an RHCOS VHD.

20 The pull secret required to authenticate your cluster.

21 Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.

IMPORTANT

To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.

22 You can optionally provide the **sshKey** value that you use to access the machines in your cluster.

NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

23 If the Azure Stack Hub environment is using an internal Certificate Authority (CA), adding the CA certificate is required.

7.3.7. Manually manage cloud credentials

The Cloud Credential Operator (CCO) only supports your cloud provider in manual mode. As a result, you must specify the identity and access management (IAM) secrets for your cloud provider.

Procedure

1. Generate the manifests by running the following command from the directory that contains the installation program:

```
$ openshift-install create manifests --dir <installation_directory>
```

   where **<installation_directory>** is the directory in which the installation program creates files.

2. From the directory that contains the installation program, obtain details of the OpenShift Container Platform release image that your **openshift-install** binary is built to use by running the following command:

```
$ openshift-install version
```

   Example output

```
release image quay.io/openshift-release-dev/ocp-release:4.y.z-x86_64
```

3. Locate all **CredentialsRequest** objects in this release image that target the cloud you are deploying on by running the following command:

```
$ oc adm release extract quay.io/openshift-release-dev/ocp-release:4.y.z-x86_64 \
  --credentials-requests \
  --cloud=azure
```

   This command creates a YAML file for each **CredentialsRequest** object.

   Sample CredentialsRequest object

```
apiVersion: cloudcredential.openshift.io/v1
kind: CredentialsRequest
metadata:
  name: <component-credentials-request>
  namespace: openshift-cloud-credential-operator
  ...
spec:
  providerSpec:
    apiVersion: cloudcredential.openshift.io/v1
    kind: AzureProviderSpec
    roleBindings:
    - role: Contributor
  ...
```

4. Create YAML files for secrets in the **openshift-install** manifests directory that you generated previously. The secrets must be stored using the namespace and secret name defined in the **spec.secretRef** for each **CredentialsRequest** object.

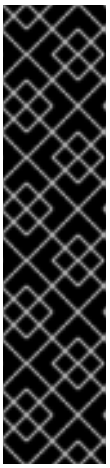
   Sample CredentialsRequest object with secrets

```
apiVersion: cloudcredential.openshift.io/v1
kind: CredentialsRequest
metadata:
  name: <component-credentials-request>
  namespace: openshift-cloud-credential-operator
  ...
```

```
spec:
  providerSpec:
    apiVersion: cloudcredential.openshift.io/v1
    kind: AzureProviderSpec
    roleBindings:
    - role: Contributor
      ...
  secretRef:
    name: <component-secret>
    namespace: <component-namespace>
  ...
```

Sample Secret object

```
apiVersion: v1
kind: Secret
metadata:
  name: <component-secret>
  namespace: <component-namespace>
data:
  azure_subscription_id: <base64_encoded_azure_subscription_id>
  azure_client_id: <base64_encoded_azure_client_id>
  azure_client_secret: <base64_encoded_azure_client_secret>
  azure_tenant_id: <base64_encoded_azure_tenant_id>
  azure_resource_prefix: <base64_encoded_azure_resource_prefix>
  azure_resourcegroup: <base64_encoded_azure_resourcegroup>
  azure_region: <base64_encoded_azure_region>
```



IMPORTANT

The release image includes **CredentialsRequest** objects for Technology Preview features that are enabled by the **TechPreviewNoUpgrade** feature set. You can identify these objects by their use of the **release.openshift.io/feature-gate: TechPreviewNoUpgrade** annotation.

- If you are not using any of these features, do not create secrets for these objects. Creating secrets for Technology Preview features that you are not using can cause the installation to fail.
- If you are using any of these features, you must create secrets for the corresponding objects.

- To find **CredentialsRequest** objects with the **TechPreviewNoUpgrade** annotation, run the following command:

```
$ grep "release.openshift.io/feature-gate" *
```

Example output

```
0000_30_capi-operator_00_credentials-request.yaml:  release.openshift.io/feature-gate:
TechPreviewNoUpgrade
```

IMPORTANT

Before upgrading a cluster that uses manually maintained credentials, you must ensure that the CCO is in an upgradeable state.

Additional resources

- Updating cloud provider resources with manually maintained credentials

7.3.8. Configuring the cluster to use an internal CA

If the Azure Stack Hub environment is using an internal Certificate Authority (CA), update the **cluster-proxy-01-config.yaml file** to configure the cluster to use the internal CA.

Prerequisites

- Create the **install-config.yaml** file and specify the certificate trust bundle in **.pem** format.
- Create the cluster manifests.

Procedure

1. From the directory in which the installation program creates files, go to the **manifests** directory.
2. Add **user-ca-bundle** to the **spec.trustedCA.name** field.

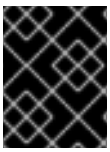
   Example cluster-proxy-01-config.yaml file

   ```
   apiVersion: config.openshift.io/v1
   kind: Proxy
   metadata:
     creationTimestamp: null
     name: cluster
   spec:
     trustedCA:
       name: user-ca-bundle
   status: {}
   ```

3. Optional: Back up the **manifests/ cluster-proxy-01-config.yaml** file. The installation program consumes the **manifests/** directory when you deploy the cluster.

7.3.9. Deploying the cluster

You can install OpenShift Container Platform on a compatible cloud platform.



IMPORTANT

You can run the **create cluster** command of the installation program only once, during initial installation.

Prerequisites

- Configure an account with the cloud platform that hosts your cluster.

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.

Procedure

- Change to the directory that contains the installation program and initialize the cluster deployment:

```
$ ./openshift-install create cluster --dir <installation_directory> \ 1
    --log-level=info 2
```

1 For **<installation_directory>**, specify the location of your customized **./install-config.yaml** file.

2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

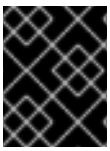
NOTE

If the cloud provider account that you configured on your host does not have sufficient permissions to deploy the cluster, the installation process stops, and the missing permissions are displayed.

Verification

When the cluster deployment completes successfully:

- The terminal displays directions for accessing your cluster, including a link to the web console and credentials for the **kubeadmin** user.
- Credential information also outputs to **<installation_directory>/.openshift_install.log**.



IMPORTANT

Do not delete the installation program or the files that the installation program creates. Both are required to delete the cluster.

Example output

```
...
INFO Install complete!
INFO To access the cluster as the system:admin user when using 'oc', run 'export
KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
INFO Access the OpenShift web-console here: https://console-openshift-
console.apps.mycluster.example.com
INFO Login to the console with user: "kubeadmin", and password: "password"
INFO Time elapsed: 36m22s
```

IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

7.3.10. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.

IMPORTANT

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.11. Download and install the new version of **oc**.

Installing the OpenShift CLI on Linux

You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the architecture in the **Product Variant** drop-down menu.
3. Select the appropriate version in the **Version** drop-down menu.
4. Click **Download Now** next to the **OpenShift v4.11 Linux Client** entry and save the file.
5. Unpack the archive:

```
$ tar xvf <file>
```

6. Place the **oc** binary in a directory that is on your **PATH**.
   To check your **PATH**, execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.
   To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
C:\> oc <command>
```

Installing the OpenShift CLI on macOS

You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 macOS Client** entry and save the file.

NOTE

For macOS arm64, choose the **OpenShift v4.11 macOS arm64 Client** entry.

4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your PATH.
   To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

7.3.11. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

Example output

```
system:admin
```

7.3.12. Logging in to the cluster by using the web console

The **kubeadmin** user exists by default after an OpenShift Container Platform installation. You can log in to your cluster as the **kubeadmin** user by using the OpenShift Container Platform web console.

Prerequisites

- You have access to the installation host.
- You completed a cluster installation and all cluster Operators are available.

Procedure

1. Obtain the password for the **kubeadmin** user from the **kubeadmin-password** file on the installation host:

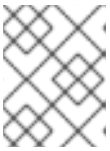
```
$ cat <installation_directory>/auth/kubeadmin-password
```

NOTE

Alternatively, you can obtain the **kubeadmin** password from the **<installation_directory>/.openshift_install.log** log file on the installation host.

2. List the OpenShift Container Platform web console route:

```
$ oc get routes -n openshift-console | grep 'console-openshift'
```



NOTE

Alternatively, you can obtain the OpenShift Container Platform route from the **<installation_directory>/.openshift_install.log** log file on the installation host.

Example output

```
console     console-openshift-console.apps.<cluster_name>.<base_domain>           console
https   reencrypt/Redirect   None
```

3. Navigate to the route detailed in the output of the preceding command in a web browser and log in as the **kubeadmin** user.

Additional resources

- Accessing the web console

7.3.13. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.11, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to OpenShift Cluster Manager Hybrid Cloud Console.

After you confirm that your OpenShift Cluster Manager Hybrid Cloud Console inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, use subscription watch to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

Additional resources

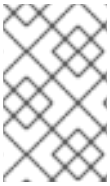
- About remote health monitoring

7.3.14. Next steps

- Validating an installation.
- Customize your cluster.
- If necessary, you can opt out of remote health reporting .
- If necessary, you can remove cloud provider credentials.

7.4. INSTALLING A CLUSTER ON AZURE STACK HUB WITH NETWORK CUSTOMIZATIONS

In OpenShift Container Platform version 4.11, you can install a cluster with a customized network configuration on infrastructure that the installation program provisions on Azure Stack Hub. By customizing your network configuration, your cluster can coexist with existing IP address allocations in your environment and integrate with existing MTU and VXLAN configurations.



NOTE

While you can select **azure** when using the installation program to deploy a cluster using installer-provisioned infrastructure, this option is only supported for the Azure Public Cloud.

7.4.1. Prerequisites

- You reviewed details about the OpenShift Container Platform installation and update processes.
- You read the documentation on selecting a cluster installation method and preparing it for users.
- You configured an Azure Stack Hub account to host the cluster.
- If you use a firewall, you configured it to allow the sites that your cluster requires access to.
- You verified that you have approximately 16 GB of local disk space. Installing the cluster requires that you download the RHCOS virtual hard disk (VHD) cluster image and upload it to your Azure Stack Hub environment so that it is accessible during deployment. Decompressing the VHD files requires this amount of local disk space.

7.4.2. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.11, you require access to the internet to install your cluster.

You must have internet access to:

- Access OpenShift Cluster Manager Hybrid Cloud Console to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access Quay.io to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.

IMPORTANT

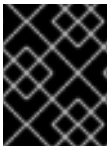
If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

7.4.3. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the **~/.ssh/authorized_keys** list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The **./openshift-install gather** command also requires the SSH public key to be in place on the cluster nodes.



IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.

NOTE

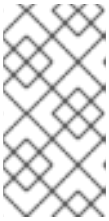
You must use a local key, not one that you configured with platform-specific approaches such as AWS key pairs.

Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N '' -f <path>/<file_name> 1
```

1 Specify the path and file name, such as **~/.ssh/id_ed25519**, of the new SSH key. If you have an existing key pair, ensure your public key is in the your **~/.ssh** directory.



NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS validated or Modules In Process cryptographic libraries on the **x86_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the **~/.ssh/id_ed25519.pub** public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the **./openshift-install gather** command.

NOTE

On some distributions, default SSH private key identities such as **~/.ssh/id_rsa** and **~/.ssh/id_dsa** are managed automatically.

   a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

Example output

```
Agent pid 31874
```

NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

1 Specify the path and file name for your SSH private key, such as **~/.ssh/id_ed25519**

Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

7.4.4. Uploading the RHCOS cluster image

You must download the RHCOS virtual hard disk (VHD) cluster image and upload it to your Azure Stack Hub environment so that it is accessible during deployment.

Prerequisites

- Configure an Azure account.

Procedure

1. Obtain the RHCOS VHD cluster image:

a. Export the URL of the RHCOS VHD to an environment variable.

```
$ export COMPRESSED_VHD_URL=$(openshift-install coreos print-stream-json | jq -r
'.architectures.x86_64.artifacts.azurestack.formats."vhd.gz".disk.location')
```

b. Download the compressed RHCOS VHD file locally.

```
$ curl -O -L ${COMPRESSED_VHD_URL}
```

2. Decompress the VHD file.

NOTE

The decompressed VHD file is approximately 16 GB, so be sure that your host system has 16 GB of free space available. The VHD file can be deleted once you have uploaded it.

3. Upload the local VHD to the Azure Stack Hub environment, making sure that the blob is publicly available. For example, you can upload the VHD to a blob using the **az** cli or the web portal.

7.4.5. Obtaining the installation program

Before you install OpenShift Container Platform, download the installation file on a local computer.

Prerequisites

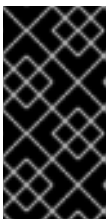
- You have a computer that runs Linux or macOS, with 500 MB of local disk space.

Procedure

1. Access the Infrastructure Provider page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select **Azure** as the cloud provider.
3. Navigate to the page for your installation type, download the installation program that corresponds with your host operating system and architecture, and place the file in the directory where you will store the installation configuration files.

IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.



IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation pull secret from the Red Hat OpenShift Cluster Manager . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

7.4.6. Manually creating the installation configuration file

When installing OpenShift Container Platform on Microsoft Azure Stack Hub, you must manually create your installation configuration file.

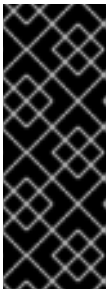
Prerequisites

- You have an SSH public key on your local machine to provide to the installation program. The key will be used for SSH authentication onto your cluster nodes for debugging and disaster recovery.
- You have obtained the OpenShift Container Platform installation program and the pull secret for your cluster.

Procedure

1. Create an installation directory to store your required installation assets in:

```
$ mkdir <installation_directory>
```



IMPORTANT

You must create a directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

2. Customize the sample **install-config.yaml** file template that is provided and save it in the **<installation_directory>**.

NOTE

You must name this configuration file **install-config.yaml**.

Make the following modifications:

a. Specify the required installation parameters.

b. Update the **platform.azure** section to specify the parameters that are specific to Azure Stack Hub.

c. Optional: Update one or more of the default configuration parameters to customize the installation.
For more information about the parameters, see "Installation configuration parameters".

3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.

IMPORTANT

The **install-config.yaml** file is consumed during the next step of the installation process. You must back it up now.

7.4.6.1. Installation configuration parameters

Before you deploy an OpenShift Container Platform cluster, you provide a customized **install-config.yaml** installation configuration file that describes the details for your environment.

NOTE

After installation, you cannot modify these parameters in the **install-config.yaml** file.

7.4.6.1.1. Required configuration parameters

Required installation configuration parameters are described in the following table:

Table 7.5. Required parameters

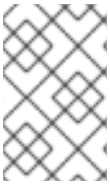
Parameter	Description	Values
apiVersion	The API version for the **install-config.yaml** content. The current version is **v1**. The installer may also support older API versions.	String
baseDomain	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the **baseDomain** and **metadata.name** parameter values that uses the **<metadata.name>.<baseDomain>** format.	A fully-qualified domain or subdomain name, such as **example.com**.
metadata	Kubernetes resource **ObjectMeta**, from which only the **name** parameter is consumed.	Object

Parameter	Description	Values
metadata.name	The name of the cluster. DNS records for the cluster are all subdomains of **{{.metadata.name}}.{{.baseDomain}}**.	String of lowercase letters, hyphens (**-**), and periods (**.**), such as **dev**.
platform	The configuration for the specific platform upon which to perform the installation: **alibabacloud**, **aws**, **baremetal**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**. For additional information about **platform.<platform>** parameters, consult the table for your specific platform that follows.	Object
pullSecret	Get a pull secret from the Red Hat OpenShift Cluster Manager to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	{ "auths":{ "cloud.openshift.com":{ "auth":"b3Blb=", "email":"you@example.com" }, "quay.io":{ "auth":"b3Blb=", "email":"you@example.com" } } }

7.4.6.1.2. Network configuration parameters

You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

Only IPv4 addresses are supported.



NOTE

Globalnet is not supported with Red Hat OpenShift Data Foundation disaster recovery solutions. For regional disaster recovery scenarios, ensure that you use a nonoverlapping range of private IP addresses for the cluster and service networks in each cluster.

Table 7.6. Network parameters

Parameter	Description	Values
networking	The configuration for the cluster network.	Object  **NOTE** You cannot modify parameters specified by the **networking** object after installation.
networking.networkType	The cluster network provider Container Network Interface (CNI) cluster network provider to install.	Either **OpenShiftSDN** or **OVNKubernetes**. **OpenShiftSDN** is a CNI provider for all-Linux networks. **OVNKubernetes** is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is **OpenShiftSDN**.
networking.clusterNetwork	The IP address blocks for pods. The default value is **10.128.0.0/14** with a host prefix of **/23**. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: `networking:` `  clusterNetwork:` `  - cidr: 10.128.0.0/14` `    hostPrefix: 23`
networking.clusterNetwork.cidr	Required if you use **networking.clusterNetwork**. An IP address block. An IPv4 network.	An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between **0** and **32**.
networking.clusterNetwork.hostPrefix	The subnet prefix length to assign to each individual node. For example, if **hostPrefix** is set to **23** then each node is assigned a **/23** subnet out of the given **cidr**. A **hostPrefix** value of **23** provides 510 (2^(32 - 23) - 2) pod IP addresses.	A subnet prefix. The default value is **23**.
networking.serviceNetwork	The IP address block for services. The default value is **172.30.0.0/16**. The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.	An array with an IP address block in CIDR format. For example: `networking:` `  serviceNetwork:` `  - 172.30.0.0/16`

Parameter	Description	Values
networking.machineNetwork	The IP address blocks for machines. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: `networking:` `  machineNetwork:` `  - cidr: 10.0.0.0/16`
networking.machineNetwork.cidr	Required if you use **networking.machineNetwork**. An IP address block. The default value is **10.0.0.0/16** for all platforms other than libvirt. For libvirt, the default value is **192.168.126.0/24**.	An IP network block in CIDR notation. For example, **10.0.0.0/16**. **NOTE** Set the **networking.machineNetwork** to match the CIDR that the preferred NIC resides in.

7.4.6.1.3. Optional configuration parameters

Optional installation configuration parameters are described in the following table:

Table 7.7. Optional parameters

Parameter	Description	Values
additionalTrustBundle	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String
capabilities	Controls the installation of optional core cluster components. You can reduce the footprint of your OpenShift Container Platform cluster by disabling optional components.	String array

Parameter	Description	Values
capabilities.baselineCapabilitySet	Selects an initial set of optional capabilities to enable. Valid values are **None**, **v4.11** and **vCurrent**. **v4.11** enables the **baremetal** Operator, the **marketplace** Operator, and the **openshift-samples** content. **vCurrent** installs the recommended set of capabilities for the current version of OpenShift Container Platform. The default value is **vCurrent**.	String
capabilities.additionalEnabledCapabilities	Extends the set of optional capabilities beyond what you specify in **baselineCapabilitySet**. Valid values are **baremetal**, **marketplace** and **openshift-samples**. You may specify multiple capabilities in this parameter.	String array
cgroupsV2	Enables Linux control groups version 2 (cgroups v2) on specific nodes in your cluster. The OpenShift Container Platform process for enabling cgroups v2 disables all cgroup version 1 controllers and hierarchies. The OpenShift Container Platform cgroups version 2 feature is in Developer Preview and is not supported by Red Hat at this time.	**true**
compute	The configuration for the machines that comprise the compute nodes.	Array of **MachinePool** objects.
compute.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** (the default).	String

Parameter	Description	Values
compute.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  **IMPORTANT** If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
compute.name	Required if you use **compute**. The name of the machine pool.	**worker**
compute.platform	Required if you use **compute**. Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the **controlPlane.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
compute.replicas	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to **2**. The default value is **3**.
controlPlane	The configuration for the machines that comprise the control plane.	Array of **MachinePool** objects.
controlPlane.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** (the default).	String

Parameter	Description	Values
controlPlane.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  **IMPORTANT** If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
controlPlane.name	Required if you use **controlPlane**. The name of the machine pool.	**master**
controlPlane.platform	Required if you use **controlPlane**. Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the **compute.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
controlPlane.replicas	The number of control plane machines to provision.	The only supported value is **3**, which is the default value.

Parameter	Description	Values
credentialsMode	The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported.  **NOTE** Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the *Cloud Credential Operator* entry in the *Cluster Operators reference* content.  **NOTE** If your AWS account has service control policies (SCP) enabled, you must configure the **credentialsMode** parameter to **Mint**, **Passthrough** or **Manual**.	**Mint**, **Passthrough**, **Manual** or an empty string (**""**).

Parameter	Description	Values
fips	Enable or disable FIPS mode. The default is **false** (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.  **IMPORTANT** To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.  **NOTE** If you are using Azure File storage, you cannot enable FIPS mode.	**false** or **true**

Parameter	Description	Values
imageContentSources	Sources and repositories for the release-image content.	Array of objects. Includes a **source** and, optionally, **mirrors**, as described in the following rows of this table.
imageContentSources.source	Required if you use **imageContentSources**. Specify the repository that users refer to, for example, in image pull specifications.	String
imageContentSources.mirrors	Specify one or more repositories that may also contain the same images.	Array of strings
publish	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	**Internal** or **External**. The default value is **External**. Setting this field to **Internal** is not supported on non-cloud platforms and IBM Cloud VPC. IMPORTANT If the value of the field is set to **Internal**, the cluster will become non-functional. For more information, refer to BZ#1953035.
sshKey	The SSH key to authenticate access to your cluster machines. NOTE For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.	For example, **sshKey: ssh-ed25519 AAAA..**.

7.4.6.1.4. Additional Azure Stack Hub configuration parameters

Additional Azure configuration parameters are described in the following table:

Table 7.8. Additional Azure Stack Hub parameters

Parameter	Description	Values
compute.platform.azure.osDisk.diskSizeGB	The Azure disk size for the VM.	Integer that represents the size of the disk in GB. The default is **128**.
compute.platform.azure.osDisk.diskType	Defines the type of disk.	**standard_LRS** or **premium_LRS**. The default is **premium_LRS**.
compute.platform.azure.type	Defines the azure instance type for compute machines.	String
controlPlane.platform.azure.osDisk.diskSizeGB	The Azure disk size for the VM.	Integer that represents the size of the disk in GB. The default is **1024**.
controlPlane.platform.azure.osDisk.diskType	Defines the type of disk.	**premium_LRS**.
controlPlane.platform.azure.type	Defines the azure instance type for control plane machines.	String
platform.azure.defaultMachinePlatform.osDisk.diskSizeGB	The Azure disk size for the VM.	Integer that represents the size of the disk in GB. The default is **128**.
platform.azure.defaultMachinePlatform.osDisk.diskType	Defines the type of disk.	**standard_LRS** or **premium_LRS**. The default is **premium_LRS**.
platform.azure.defaultMachinePlatform.type	The Azure instance type for control plane and compute machines.	The Azure instance type.
platform.azure.armEndpoint	The URL of the Azure Resource Manager endpoint that your Azure Stack Hub operator provides.	String
platform.azure.baseDomainResourceGroupName	The name of the resource group that contains the DNS zone for your base domain.	String, for example **production_cluster**.
platform.azure.region	The name of your Azure Stack Hub local region.	String

Parameter	Description	Values
platform.azure.resourceGroupName	The name of an already existing resource group to install your cluster to. This resource group must be empty and only used for this specific cluster; the cluster components assume ownership of all resources in the resource group. If you limit the service principal scope of the installation program to this resource group, you must ensure all other resources used by the installation program in your environment have the necessary permissions, such as the public DNS zone and virtual network. Destroying the cluster by using the installation program deletes this resource group.	String, for example **existing_resource_group**.
platform.azure.outboundType	The outbound routing strategy used to connect your cluster to the internet. If you are using user-defined routing, you must have pre-existing networking available where the outbound routing has already been configured prior to installing a cluster. The installation program is not responsible for configuring user-defined routing.	**LoadBalancer** or **UserDefinedRouting**. The default is **LoadBalancer**.
platform.azure.cloudName	The name of the Azure cloud environment that is used to configure the Azure SDK with the appropriate Azure API endpoints.	**AzureStackCloud**
clusterOSImage	The URL of a storage blob in the Azure Stack environment that contains an RHCOS VHD.	String, for example, https://vhdsa.blob.example.example.com/vhd/rhcos-410.84.202112040202-0-azurestack.x86_64.vhd

7.4.6.2. Sample customized install-config.yaml file for Azure Stack Hub

You can customize the **install-config.yaml** file to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.

IMPORTANT

This sample YAML file is provided for reference only. Use it as a resource to enter parameter values into the installation configuration file that you created manually.

```
apiVersion: v1
```

```
baseDomain: example.com (1)
credentialsMode: Manual
controlPlane: (2) (3)
  name: master
  platform:
    azure:
      osDisk:
        diskSizeGB: 1024 (4)
        diskType: premium_LRS
  replicas: 3
compute: (5)
- name: worker
  platform:
    azure:
      osDisk:
        diskSizeGB: 512 (6)
        diskType: premium_LRS
  replicas: 3
metadata:
  name: test-cluster (7) (8)
networking:
  clusterNetwork:
  - cidr: 10.128.0.0/14
    hostPrefix: 23
  machineNetwork:
  - cidr: 10.0.0.0/16
  networkType: OpenShiftSDN
  serviceNetwork:
  - 172.30.0.0/16
platform:
  azure:
    armEndpoint: azurestack_arm_endpoint (9) (10)
    baseDomainResourceGroupName: resource_group (11) (12)
    region: azure_stack_local_region (13) (14)
    resourceGroupName: existing_resource_group (15)
    outboundType: Loadbalancer
    cloudName: AzureStackCloud (16)
    clusterOSimage: https://vhdsa.blob.example.example.com/vhd/rhcos-410.84.202112040202-0-
azurestack.x86_64.vhd (17) (18)
pullSecret: '{"auths": ...}' (19) (20)
fips: false (21)
sshKey: ssh-ed25519 AAAA... (22)
additionalTrustBundle: | (23)
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
```

(1) (7) (9) (11) (13) (16) (17) (19) Required.

(2) (5) If you do not provide these parameters and values, the installation program provides the default value.

(3) The **controlPlane** section is a single mapping, but the **compute** section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section

must begin with a hyphen, **-**, and the first line of the **controlPlane** section must not. Although both sections currently define a single machine pool, it is possible that future versions of OpenShift Container Platform will support defining multiple compute pools during installation. Only one control plane pool is used.

4 6 You can specify the size of the disk to use in GB. Minimum recommendation for control plane nodes is 1024 GB.

8 The name of the cluster.

10 The Azure Resource Manager endpoint that your Azure Stack Hub operator provides.

12 The name of the resource group that contains the DNS zone for your base domain.

14 The name of your Azure Stack Hub local region.

15 The name of an existing resource group to install your cluster to. If undefined, a new resource group is created for the cluster.

18 The URL of a storage blob in the Azure Stack environment that contains an RHCOS VHD.

20 The pull secret required to authenticate your cluster.

21 Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.

IMPORTANT

To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.

22 You can optionally provide the **sshKey** value that you use to access the machines in your cluster.

NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

23 If the Azure Stack Hub environment is using an internal Certificate Authority (CA), adding the CA certificate is required.

7.4.7. Manually manage cloud credentials

The Cloud Credential Operator (CCO) only supports your cloud provider in manual mode. As a result, you must specify the identity and access management (IAM) secrets for your cloud provider.

Procedure

1. Generate the manifests by running the following command from the directory that contains the installation program:

```
$ openshift-install create manifests --dir <installation_directory>
```

   where **<installation_directory>** is the directory in which the installation program creates files.

2. From the directory that contains the installation program, obtain details of the OpenShift Container Platform release image that your **openshift-install** binary is built to use by running the following command:

```
$ openshift-install version
```

   Example output

```
release image quay.io/openshift-release-dev/ocp-release:4.y.z-x86_64
```

3. Locate all **CredentialsRequest** objects in this release image that target the cloud you are deploying on by running the following command:

```
$ oc adm release extract quay.io/openshift-release-dev/ocp-release:4.y.z-x86_64 \
  --credentials-requests \
  --cloud=azure
```

   This command creates a YAML file for each **CredentialsRequest** object.

   Sample CredentialsRequest object

```
apiVersion: cloudcredential.openshift.io/v1
kind: CredentialsRequest
metadata:
  name: <component-credentials-request>
  namespace: openshift-cloud-credential-operator
  ...
spec:
  providerSpec:
    apiVersion: cloudcredential.openshift.io/v1
    kind: AzureProviderSpec
    roleBindings:
    - role: Contributor
  ...
```

4. Create YAML files for secrets in the **openshift-install** manifests directory that you generated previously. The secrets must be stored using the namespace and secret name defined in the **spec.secretRef** for each **CredentialsRequest** object.

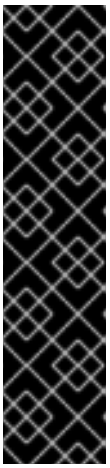
   Sample CredentialsRequest object with secrets

```
apiVersion: cloudcredential.openshift.io/v1
kind: CredentialsRequest
metadata:
  name: <component-credentials-request>
  namespace: openshift-cloud-credential-operator
  ...
```

```
spec:
  providerSpec:
    apiVersion: cloudcredential.openshift.io/v1
    kind: AzureProviderSpec
    roleBindings:
    - role: Contributor
      ...
  secretRef:
    name: <component-secret>
    namespace: <component-namespace>
  ...
```

Sample Secret object

```
apiVersion: v1
kind: Secret
metadata:
  name: <component-secret>
  namespace: <component-namespace>
data:
  azure_subscription_id: <base64_encoded_azure_subscription_id>
  azure_client_id: <base64_encoded_azure_client_id>
  azure_client_secret: <base64_encoded_azure_client_secret>
  azure_tenant_id: <base64_encoded_azure_tenant_id>
  azure_resource_prefix: <base64_encoded_azure_resource_prefix>
  azure_resourcegroup: <base64_encoded_azure_resourcegroup>
  azure_region: <base64_encoded_azure_region>
```



IMPORTANT

The release image includes **CredentialsRequest** objects for Technology Preview features that are enabled by the **TechPreviewNoUpgrade** feature set. You can identify these objects by their use of the **release.openshift.io/feature-gate: TechPreviewNoUpgrade** annotation.

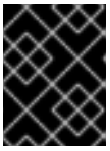
- If you are not using any of these features, do not create secrets for these objects. Creating secrets for Technology Preview features that you are not using can cause the installation to fail.
- If you are using any of these features, you must create secrets for the corresponding objects.

- To find **CredentialsRequest** objects with the **TechPreviewNoUpgrade** annotation, run the following command:

```
$ grep "release.openshift.io/feature-gate" *
```

Example output

```
0000_30_capi-operator_00_credentials-request.yaml:  release.openshift.io/feature-gate:
TechPreviewNoUpgrade
```



IMPORTANT

Before upgrading a cluster that uses manually maintained credentials, you must ensure that the CCO is in an upgradeable state.

Additional resources

- Updating a cluster using the web console
- Updating a cluster using the CLI

7.4.8. Configuring the cluster to use an internal CA

If the Azure Stack Hub environment is using an internal Certificate Authority (CA), update the **cluster-proxy-01-config.yaml file** to configure the cluster to use the internal CA.

Prerequisites

- Create the **install-config.yaml** file and specify the certificate trust bundle in **.pem** format.
- Create the cluster manifests.

Procedure

1. From the directory in which the installation program creates files, go to the **manifests** directory.
2. Add **user-ca-bundle** to the **spec.trustedCA.name** field.

   Example cluster-proxy-01-config.yaml file

```
apiVersion: config.openshift.io/v1
kind: Proxy
metadata:
  creationTimestamp: null
  name: cluster
spec:
  trustedCA:
    name: user-ca-bundle
status: {}
```

3. Optional: Back up the **manifests/ cluster-proxy-01-config.yaml** file. The installation program consumes the **manifests/** directory when you deploy the cluster.

7.4.9. Network configuration phases

There are two phases prior to OpenShift Container Platform installation where you can customize the network configuration.

Phase 1

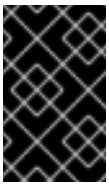
You can customize the following network-related fields in the **install-config.yaml** file before you create the manifest files:

- **networking.networkType**

- **networking.clusterNetwork**
- **networking.serviceNetwork**
- **networking.machineNetwork**
  For more information on these fields, refer to *Installation configuration parameters*.

NOTE

Set the **networking.machineNetwork** to match the CIDR that the preferred NIC resides in.



IMPORTANT

The CIDR range **172.17.0.0/16** is reserved by libVirt. You cannot use this range or any range that overlaps with this range for any networks in your cluster.

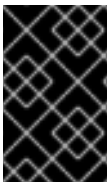
Phase 2

After creating the manifest files by running **openshift-install create manifests**, you can define a customized Cluster Network Operator manifest with only the fields you want to modify. You can use the manifest to specify advanced network configuration.

You cannot override the values specified in phase 1 in the **install-config.yaml** file during phase 2. However, you can further customize the cluster network provider during phase 2.

7.4.10. Specifying advanced network configuration

You can use advanced network configuration for your cluster network provider to integrate your cluster into your existing network environment. You can specify advanced network configuration only before you install the cluster.



IMPORTANT

Customizing your network configuration by modifying the OpenShift Container Platform manifest files created by the installation program is not supported. Applying a manifest file that you create, as in the following procedure, is supported.

Prerequisites

- You have created the **install-config.yaml** file and completed any modifications to it.

Procedure

1. Change to the directory that contains the installation program and create the manifests:

```
$ ./openshift-install create manifests --dir <installation_directory> 1
```

1 **<installation_directory>** specifies the name of the directory that contains the **install-config.yaml** file for your cluster.

2. Create a stub manifest file for the advanced network configuration that is named **cluster-network-03-config.yml** in the **<installation_directory>/manifests/** directory:

```
apiVersion: operator.openshift.io/v1
kind: Network
metadata:
  name: cluster
spec:
```

3. Specify the advanced network configuration for your cluster in the **cluster-network-03-config.yml** file, such as in the following examples:

   Specify a different VXLAN port for the OpenShift SDN network provider

```
apiVersion: operator.openshift.io/v1
kind: Network
metadata:
  name: cluster
spec:
  defaultNetwork:
    openshiftSDNConfig:
      vxlanPort: 4800
```

   Enable IPsec for the OVN-Kubernetes network provider

```
apiVersion: operator.openshift.io/v1
kind: Network
metadata:
  name: cluster
spec:
  defaultNetwork:
    ovnKubernetesConfig:
      ipsecConfig: {}
```

4. Optional: Back up the **manifests/cluster-network-03-config.yml** file. The installation program consumes the **manifests/** directory when you create the Ignition config files.

7.4.11. Cluster Network Operator configuration

The configuration for the cluster network is specified as part of the Cluster Network Operator (CNO) configuration and stored in a custom resource (CR) object that is named **cluster**. The CR specifies the fields for the **Network** API in the **operator.openshift.io** API group.

The CNO configuration inherits the following fields during cluster installation from the **Network** API in the **Network.config.openshift.io** API group and these fields cannot be changed:

clusterNetwork

IP address pools from which pod IP addresses are allocated.

serviceNetwork

IP address pool for services.

defaultNetwork.type

Cluster network provider, such as OpenShift SDN or OVN-Kubernetes.

You can specify the cluster network provider configuration for your cluster by setting the fields for the **defaultNetwork** object in the CNO object named **cluster**.

7.4.11.1. Cluster Network Operator configuration object

The fields for the Cluster Network Operator (CNO) are described in the following table:

Table 7.9. Cluster Network Operator configuration object

Field	Type	Description
metadata.name	**string**	The name of the CNO object. This name is always **cluster**.
spec.clusterNetwork	**array**	A list specifying the blocks of IP addresses from which pod IP addresses are allocated and the subnet prefix length assigned to each individual node in the cluster. For example: `spec:` `  clusterNetwork:` `  - cidr: 10.128.0.0/19` `  hostPrefix: 23` `  - cidr: 10.128.32.0/19` `  hostPrefix: 23` You can customize this field only in the **install-config.yaml** file before you create the manifests. The value is read-only in the manifest file.
spec.serviceNetwork	**array**	A block of IP addresses for services. The OpenShift SDN and OVN-Kubernetes Container Network Interface (CNI) network providers support only a single IP address block for the service network. For example: `spec:` `  serviceNetwork:` `  - 172.30.0.0/14` You can customize this field only in the **install-config.yaml** file before you create the manifests. The value is read-only in the manifest file.
spec.defaultNetwork	**object**	Configures the Container Network Interface (CNI) cluster network provider for the cluster network.
spec.kubeProxyConfig	**object**	The fields for this object specify the kube-proxy configuration. If you are using the OVN-Kubernetes cluster network provider, the kube-proxy configuration has no effect.

defaultNetwork object configuration

The values for the **defaultNetwork** object are defined in the following table:

Table 7.10. defaultNetwork object

Field	Type	Description
type	**string**	Either **OpenShiftSDN** or **OVNKubernetes**. The cluster network provider is selected during installation. This value cannot be changed after cluster installation.  **NOTE** OpenShift Container Platform uses the OpenShift SDN Container Network Interface (CNI) cluster network provider by default.
openshiftSDNConfig	**object**	This object is only valid for the OpenShift SDN cluster network provider.
ovnKubernetesConfig	**object**	This object is only valid for the OVN-Kubernetes cluster network provider.

Configuration for the OpenShift SDN CNI cluster network provider
The following table describes the configuration fields for the OpenShift SDN Container Network Interface (CNI) cluster network provider.

Table 7.11. **openshiftSDNConfig** object

Field	Type	Description
mode	**string**	Configures the network isolation mode for OpenShift SDN. The default value is **NetworkPolicy**. The values **Multitenant** and **Subnet** are available for backwards compatibility with OpenShift Container Platform 3.x but are not recommended. This value cannot be changed after cluster installation.

Field	Type	Description
mtu	**integer**	The maximum transmission unit (MTU) for the VXLAN overlay network. This is detected automatically based on the MTU of the primary network interface. You do not normally need to override the detected MTU. If the auto-detected value is not what you expect it to be, confirm that the MTU on the primary network interface on your nodes is correct. You cannot use this option to change the MTU value of the primary network interface on the nodes. If your cluster requires different MTU values for different nodes, you must set this value to **50** less than the lowest MTU value in your cluster. For example, if some nodes in your cluster have an MTU of **9001**, and some have an MTU of**1500**, you must set this value to **1450**. This value cannot be changed after cluster installation.
vxlanPort	**integer**	The port to use for all VXLAN packets. The default value is **4789**. This value cannot be changed after cluster installation. If you are running in a virtualized environment with existing nodes that are part of another VXLAN network, then you might be required to change this. For example, when running an OpenShift SDN overlay on top of VMware NSX-T, you must select an alternate port for the VXLAN, because both SDNs use the same default VXLAN port number. On Amazon Web Services (AWS), you can select an alternate port for the VXLAN between port **9000** and port **9999**.

Example OpenShift SDN configuration

```
defaultNetwork:
  type: OpenShiftSDN
  openshiftSDNConfig:
    mode: NetworkPolicy
    mtu: 1450
    vxlanPort: 4789
```

Configuration for the OVN-Kubernetes CNI cluster network provider

The following table describes the configuration fields for the OVN-Kubernetes CNI cluster network provider.

Table 7.12. ovnKubernetesConfig object

Field	Type	Description

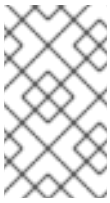
Field	Type	Description
mtu	**integer**	The maximum transmission unit (MTU) for the Geneve (Generic Network Virtualization Encapsulation) overlay network. This is detected automatically based on the MTU of the primary network interface. You do not normally need to override the detected MTU. If the auto-detected value is not what you expect it to be, confirm that the MTU on the primary network interface on your nodes is correct. You cannot use this option to change the MTU value of the primary network interface on the nodes. If your cluster requires different MTU values for different nodes, you must set this value to **100** less than the lowest MTU value in your cluster. For example, if some nodes in your cluster have an MTU of **9001**, and some have an MTU of**1500**, you must set this value to **1400**.
genevePort	**integer**	The port to use for all Geneve packets. The default value is **6081**. This value cannot be changed after cluster installation.
ipsecConfig	**object**	Specify an empty object to enable IPsec encryption.
policyAuditConfig	**object**	Specify a configuration object for customizing network policy audit logging. If unset, the defaults audit log settings are used.
gatewayConfig	**object**	Optional: Specify a configuration object for customizing how egress traffic is sent to the node gateway.  NOTE While migrating egress traffic, you can expect some disruption to workloads and service traffic until the Cluster Network Operator (CNO) successfully rolls out the changes.

Table 7.13. **policyAuditConfig** object

Field	Type	Description
rateLimit	integer	The maximum number of messages to generate every second per node. The default value is **20** messages per second.
maxFileSize	integer	The maximum size for the audit log in bytes. The default value is **50000000** or 50 MB.

Field	Type	Description
destination	string	One of the following additional audit log targets: **libc** The libc **syslog()** function of the journald process on the host. **udp:<host>:<port>** A syslog server. Replace **<host>:<port>** with the host and port of the syslog server. **unix:<file>** A Unix Domain Socket file specified by **<file>**. **null** Do not send the audit logs to any additional target.
syslogFacility	string	The syslog facility, such as **kern**, as defined by RFC5424. The default value is **local0**.

Table 7.14. **gatewayConfig** object

Field	Type	Description
routingViaHost	**boolean**	Set this field to **true** to send egress traffic from pods to the host networking stack. For highly-specialized installations and applications that rely on manually configured routes in the kernel routing table, you might want to route egress traffic to the host networking stack. By default, egress traffic is processed in OVN to exit the cluster and is not affected by specialized routes in the kernel routing table. The default value is **false**. This field has an interaction with the Open vSwitch hardware offloading feature. If you set this field to **true**, you do not receive the performance benefits of the offloading because egress traffic is processed by the host networking stack.

Example OVN-Kubernetes configuration with IPSec enabled

```
defaultNetwork:
  type: OVNKubernetes
  ovnKubernetesConfig:
    mtu: 1400
    genevePort: 6081
    ipsecConfig: {}
```

kubeProxyConfig object configuration

The values for the **kubeProxyConfig** object are defined in the following table:

Table 7.15. **kubeProxyConfig** object

Field	Type	Description
iptablesSyncPeriod	**string**	The refresh period for **iptables** rules. The default value is **30s**. Valid suffixes include **s**, **m**, and **h** and are described in the Go **time** package documentation. NOTE Because of performance improvements introduced in OpenShift Container Platform 4.3 and greater, adjusting the **iptablesSyncPeriod** parameter is no longer necessary.
proxyArguments.iptables-min-sync-period	**array**	The minimum duration before refreshing **iptables** rules. This field ensures that the refresh does not happen too frequently. Valid suffixes include **s**, **m**, and **h** and are described in the Go **time** package. The default value is: kubeProxyConfig: proxyArguments: iptables-min-sync-period: - 0s

7.4.12. Configuring hybrid networking with OVN-Kubernetes

You can configure your cluster to use hybrid networking with OVN-Kubernetes. This allows a hybrid cluster that supports different node networking configurations. For example, this is necessary to run both Linux and Windows nodes in a cluster.

IMPORTANT

You must configure hybrid networking with OVN-Kubernetes during the installation of your cluster. You cannot switch to hybrid networking after the installation process.

Prerequisites

- You defined **OVNKubernetes** for the **networking.networkType** parameter in the **install-config.yaml** file. See the installation documentation for configuring OpenShift Container Platform network customizations on your chosen cloud provider for more information.

Procedure

1. Change to the directory that contains the installation program and create the manifests:

```
$ ./openshift-install create manifests --dir <installation_directory>
```

where:

<installation_directory>

Specifies the name of the directory that contains the **install-config.yaml** file for your cluster.

2. Create a stub manifest file for the advanced network configuration that is named **cluster-network-03-config.yml** in the **<installation_directory>/manifests/** directory:

```
$ cat <<EOF > <installation_directory>/manifests/cluster-network-03-config.yml
apiVersion: operator.openshift.io/v1
kind: Network
metadata:
  name: cluster
spec:
EOF
```

where:

<installation_directory>

Specifies the directory name that contains the **manifests/** directory for your cluster.

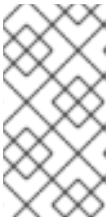
3. Open the **cluster-network-03-config.yml** file in an editor and configure OVN-Kubernetes with hybrid networking, such as in the following example:

Specify a hybrid networking configuration

```
apiVersion: operator.openshift.io/v1
kind: Network
metadata:
  name: cluster
spec:
  defaultNetwork:
    ovnKubernetesConfig:
      hybridOverlayConfig:
        hybridClusterNetwork: 1
        - cidr: 10.132.0.0/14
          hostPrefix: 23
        hybridOverlayVXLANPort: 9898 2
```

1 Specify the CIDR configuration used for nodes on the additional overlay network. The **hybridClusterNetwork** CIDR cannot overlap with the **clusterNetwork** CIDR.

2 Specify a custom VXLAN port for the additional overlay network. This is required for running Windows nodes in a cluster installed on vSphere, and must not be configured for any other cloud provider. The custom port can be any open port excluding the default **4789** port. For more information on this requirement, see the Microsoft documentation on Pod-to-pod connectivity between hosts is broken.

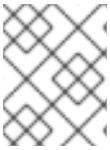


NOTE

Windows Server Long-Term Servicing Channel (LTSC): Windows Server 2019 is not supported on clusters with a custom **hybridOverlayVXLANPort** value because this Windows server version does not support selecting a custom VXLAN port.

4. Save the **cluster-network-03-config.yml** file and quit the text editor.

5. Optional: Back up the **manifests/cluster-network-03-config.yml** file. The installation program deletes the **manifests/** directory when creating the cluster.



NOTE

For more information on using Linux and Windows nodes in the same cluster, see Understanding Windows container workloads.

7.4.13. Deploying the cluster

You can install OpenShift Container Platform on a compatible cloud platform.

IMPORTANT

You can run the **create cluster** command of the installation program only once, during initial installation.

Prerequisites

- Configure an account with the cloud platform that hosts your cluster.
- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.

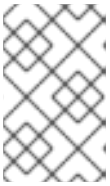
Procedure

- Change to the directory that contains the installation program and initialize the cluster deployment:

```
$ ./openshift-install create cluster --dir <installation_directory> \ 1
    --log-level=info 2
```

1 For **<installation_directory>**, specify the location of your customized **./install-config.yaml** file.

2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.



NOTE

If the cloud provider account that you configured on your host does not have sufficient permissions to deploy the cluster, the installation process stops, and the missing permissions are displayed.

Verification

When the cluster deployment completes successfully:

- The terminal displays directions for accessing your cluster, including a link to the web console and credentials for the **kubeadmin** user.
- Credential information also outputs to **<installation_directory>/.openshift_install.log**.

IMPORTANT

Do not delete the installation program or the files that the installation program creates. Both are required to delete the cluster.

Example output

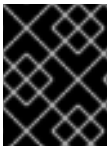
```
...
INFO Install complete!
INFO To access the cluster as the system:admin user when using 'oc', run 'export
KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
INFO Access the OpenShift web-console here: https://console-openshift-
console.apps.mycluster.example.com
INFO Login to the console with user: "kubeadmin", and password: "password"
INFO Time elapsed: 36m22s
```

IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

7.4.14. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.



IMPORTANT

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.11. Download and install the new version of **oc**.

Installing the OpenShift CLI on Linux

You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the architecture in the **Product Variant** drop-down menu.
3. Select the appropriate version in the **Version** drop-down menu.

4. Click **Download Now** next to the **OpenShift v4.11 Linux Client** entry and save the file.
5. Unpack the archive:

```
$ tar xvf <file>
```

6. Place the **oc** binary in a directory that is on your **PATH**.
   To check your **PATH**, execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.
   To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
C:\> oc <command>
```

Installing the OpenShift CLI on macOS

You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 macOS Client** entry and save the file.

NOTE

For macOS arm64, choose the **OpenShift v4.11 macOS arm64 Client** entry.

4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your PATH.
   To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

7.4.15. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

Example output

```
system:admin
```

7.4.16. Logging in to the cluster by using the web console

The **kubeadmin** user exists by default after an OpenShift Container Platform installation. You can log in to your cluster as the **kubeadmin** user by using the OpenShift Container Platform web console.

Prerequisites

- You have access to the installation host.
- You completed a cluster installation and all cluster Operators are available.

Procedure

1. Obtain the password for the **kubeadmin** user from the **kubeadmin-password** file on the installation host:

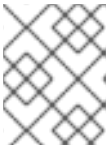
```
$ cat <installation_directory>/auth/kubeadmin-password
```

NOTE

Alternatively, you can obtain the **kubeadmin** password from the **<installation_directory>/.openshift_install.log** log file on the installation host.

2. List the OpenShift Container Platform web console route:

```
$ oc get routes -n openshift-console | grep 'console-openshift'
```



NOTE

Alternatively, you can obtain the OpenShift Container Platform route from the **<installation_directory>/.openshift_install.log** log file on the installation host.

Example output

```
console     console-openshift-console.apps.<cluster_name>.<base_domain>           console
https   reencrypt/Redirect   None
```

3. Navigate to the route detailed in the output of the preceding command in a web browser and log in as the **kubeadmin** user.

Additional resources

- Accessing the web console.

7.4.17. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.11, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to OpenShift Cluster Manager Hybrid Cloud Console.

After you confirm that your OpenShift Cluster Manager Hybrid Cloud Console inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, use subscription watch to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

Additional resources

- About remote health monitoring

7.4.18. Next steps

- Validating an installation.
- Customize your cluster.
- If necessary, you can opt out of remote health reporting .
- If necessary, you can remove cloud provider credentials.

7.5. INSTALLING A CLUSTER ON AZURE STACK HUB USING ARM TEMPLATES

In OpenShift Container Platform version 4.11, you can install a cluster on Microsoft Azure Stack Hub by using infrastructure that you provide.

Several Azure Resource Manager (ARM) templates are provided to assist in completing these steps or to help model your own.

IMPORTANT

The steps for performing a user-provisioned infrastructure installation are provided as an example only. Installing a cluster with infrastructure you provide requires knowledge of the cloud provider and the installation process of OpenShift Container Platform. Several ARM templates are provided to assist in completing these steps or to help model your own. You are also free to create the required resources through other methods; the templates are just an example.

7.5.1. Prerequisites

- You reviewed details about the OpenShift Container Platform installation and update processes.
- You read the documentation on selecting a cluster installation method and preparing it for users.
- You configured an Azure Stack Hub account to host the cluster.
- You downloaded the Azure CLI and installed it on your computer. See Install the Azure CLI in the Azure documentation. The documentation below was tested using version **2.28.0** of the Azure CLI. Azure CLI commands might perform differently based on the version you use.
- If you use a firewall and plan to use the Telemetry service, you configured the firewall to allow the sites that your cluster requires access to.

NOTE

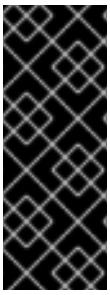
Be sure to also review this site list if you are configuring a proxy.

7.5.2. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.11, you require access to the internet to install your cluster.

You must have internet access to:

- Access OpenShift Cluster Manager Hybrid Cloud Console to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access Quay.io to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.



IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

7.5.3. Configuring your Azure Stack Hub project

Before you can install OpenShift Container Platform, you must configure an Azure project to host it.

IMPORTANT

All Azure Stack Hub resources that are available through public endpoints are subject to resource name restrictions, and you cannot create resources that use certain terms. For a list of terms that Azure Stack Hub restricts, see Resolve reserved resource name errors in the Azure documentation.

7.5.3.1. Azure Stack Hub account limits

The OpenShift Container Platform cluster uses a number of Microsoft Azure Stack Hub components, and the default Quota types in Azure Stack Hub affect your ability to install OpenShift Container Platform clusters.

The following table summarizes the Azure Stack Hub components whose limits can impact your ability to install and run OpenShift Container Platform clusters.

Component	Number of components required by default	Description

Component	Number of components required by default	Description
vCPU	56	A default cluster requires 56 vCPUs, so you must increase the account limit. By default, each cluster creates the following instances: ● One bootstrap machine, which is removed after installation ● Three control plane machines ● Three compute machines Because the bootstrap, control plane, and worker machines use **Standard_DS4_v2** virtual machines, which use 8 vCPUs, a default cluster requires 56 vCPUs. The bootstrap node VM is used only during installation. To deploy more worker nodes, enable autoscaling, deploy large workloads, or use a different instance type, you must further increase the vCPU limit for your account to ensure that your cluster can deploy the machines that you require.
VNet	1	Each default cluster requires one Virtual Network (VNet), which contains two subnets.
Network interfaces	7	Each default cluster requires seven network interfaces. If you create more machines or your deployed workloads create load balancers, your cluster uses more network interfaces.
Network security groups	2	Each cluster creates network security groups for each subnet in the VNet. The default cluster creates network security groups for the control plane and for the compute node subnets: **controlplane** — Allows the control plane machines to be reached on port 6443 from anywhere **node** — Allows worker nodes to be reached from the internet on ports 80 and 443

Component	Number of components required by default	Description
Network load balancers	3	Each cluster creates the following load balancers: **default** — Public IP address that load balances requests to ports 80 and 443 across worker machines **internal** — Private IP address that load balances requests to ports 6443 and 22623 across control plane machines **external** — Public IP address that load balances requests to port 6443 across control plane machines If your applications create more Kubernetes **LoadBalancer** service objects, your cluster uses more load balancers.
Public IP addresses	2	The public load balancer uses a public IP address. The bootstrap machine also uses a public IP address so that you can SSH into the machine to troubleshoot issues during installation. The IP address for the bootstrap node is used only during installation.
Private IP addresses	7	The internal load balancer, each of the three control plane machines, and each of the three worker machines each use a private IP address.

Additional resources

- Optimizing storage.

7.5.3.2. Configuring a DNS zone in Azure Stack Hub

To successfully install OpenShift Container Platform on Azure Stack Hub, you must create DNS records in an Azure Stack Hub DNS zone. The DNS zone must be authoritative for the domain. To delegate a registrar's DNS zone to Azure Stack Hub, see Microsoft's documentation for Azure Stack Hub datacenter DNS integration.

You can view Azure's DNS solution by visiting this example for creating DNS zones.

7.5.3.3. Certificate signing requests management

Because your cluster has limited access to automatic machine management when you use infrastructure that you provision, you must provide a mechanism for approving cluster certificate signing requests (CSRs) after installation. The **kube-controller-manager** only approves the kubelet client CSRs. The **machine-approver** cannot guarantee the validity of a serving certificate that is requested by using kubelet credentials because it cannot confirm that the correct machine issued the request. You must determine and implement a method of verifying the validity of the kubelet serving certificate requests and approving them.

7.5.3.4. Required Azure Stack Hub roles

Your Microsoft Azure Stack Hub account must have the following roles for the subscription that you use:

- **Owner**

To set roles on the Azure portal, see the Manage access to resources in Azure Stack Hub with role-based access control in the Microsoft documentation.

7.5.3.5. Creating a service principal

Because OpenShift Container Platform and its installation program create Microsoft Azure resources by using the Azure Resource Manager, you must create a service principal to represent it.

Prerequisites

- Install or update the Azure CLI.
- Your Azure account has the required roles for the subscription that you use.

Procedure

1. Register your environment:

```
$ az cloud register -n AzureStackCloud --endpoint-resource-manager <endpoint> 1
```

1 Specify the Azure Resource Manager endpoint, `https://management.<region>.<fqdn>/`.

   See the Microsoft documentation for details.

2. Set the active environment:

```
$ az cloud set -n AzureStackCloud
```

3. Update your environment configuration to use the specific API version for Azure Stack Hub:

```
$ az cloud update --profile 2019-03-01-hybrid
```

4. Log in to the Azure CLI:

```
$ az login
```

   If you are in a multitenant environment, you must also supply the tenant ID.

5. If your Azure account uses subscriptions, ensure that you are using the right subscription:

   a. View the list of available accounts and record the **tenantId** value for the subscription you want to use for your cluster:

```
$ az account list --refresh
```

   Example output

```
[
  {
```

```
    "cloudName": AzureStackCloud",
    "id": "9bab1460-96d5-40b3-a78e-17b15e978a80",
    "isDefault": true,
    "name": "Subscription Name",
    "state": "Enabled",
    "tenantId": "6057c7e9-b3ae-489d-a54e-de3f6bf6a8ee",
    "user": {
      "name": "you@example.com",
      "type": "user"
    }
  }
]
```

b. View your active account details and confirm that the **tenantId** value matches the subscription you want to use:

```
$ az account show
```

Example output

```
{
  "environmentName": AzureStackCloud",
  "id": "9bab1460-96d5-40b3-a78e-17b15e978a80",
  "isDefault": true,
  "name": "Subscription Name",
  "state": "Enabled",
  "tenantId": "6057c7e9-b3ae-489d-a54e-de3f6bf6a8ee", (1)
  "user": {
    "name": "you@example.com",
    "type": "user"
  }
}
```

(1) Ensure that the value of the **tenantId** parameter is the correct subscription ID.

c. If you are not using the right subscription, change the active subscription:

```
$ az account set -s <subscription_id> (1)
```

(1) Specify the subscription ID.

d. Verify the subscription ID update:

```
$ az account show
```

Example output

```
{
  "environmentName": AzureStackCloud",
  "id": "33212d16-bdf6-45cb-b038-f6565b61edda",
  "isDefault": true,
  "name": "Subscription Name",
```

```
  "state": "Enabled",
  "tenantId": "8049c7e9-c3de-762d-a54e-dc3f6be6a7ee",
  "user": {
    "name": "you@example.com",
    "type": "user"
  }
}
```

6. Record the **tenantId** and **id** parameter values from the output. You need these values during the OpenShift Container Platform installation.

7. Create the service principal for your account:

```
$ az ad sp create-for-rbac --role Contributor --name <service_principal> \ 1
  --scopes /subscriptions/<subscription_id> 2
  --years <years> 3
```

1. Specify the service principal name.
2. Specify the subscription ID.
3. Specify the number of years. By default, a service principal expires in one year. By using the **--years** option you can extend the validity of your service principal.

Example output

```
Creating 'Contributor' role assignment under scope '/subscriptions/<subscription_id>'
The output includes credentials that you must protect. Be sure that you do not
include these credentials in your code or check the credentials into your source
control. For more information, see https://aka.ms/azadsp-cli
{
  "appId": "ac461d78-bf4b-4387-ad16-7e32e328aec6",
  "displayName": <service_principal>",
  "password": "00000000-0000-0000-0000-000000000000",
  "tenantId": "8049c7e9-c3de-762d-a54e-dc3f6be6a7ee"
}
```

8. Record the values of the **appId** and **password** parameters from the previous output. You need these values during OpenShift Container Platform installation.

Additional resources

- For more information about CCO modes, see About the Cloud Credential Operator.

7.5.4. Obtaining the installation program

Before you install OpenShift Container Platform, download the installation file on a local computer.

Prerequisites

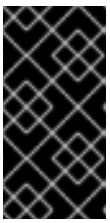
- You have a computer that runs Linux or macOS, with 500 MB of local disk space.

Procedure

1. Access the Infrastructure Provider page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.

2. Select **Azure** as the cloud provider.

3. Navigate to the page for your installation type, download the installation program that corresponds with your host operating system and architecture, and place the file in the directory where you will store the installation configuration files.



IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.

IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

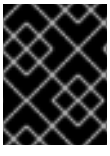
5. Download your installation pull secret from the Red Hat OpenShift Cluster Manager . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

7.5.5. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the **~/.ssh/authorized_keys** list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The **./openshift-install gather** command also requires the SSH public key to be in place on the cluster nodes.



IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.

NOTE

You must use a local key, not one that you configured with platform-specific approaches such as AWS key pairs.

Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N '' -f <path>/<file_name> 1
```

1 Specify the path and file name, such as ~/**.ssh/id_ed25519**, of the new SSH key. If you have an existing key pair, ensure your public key is in the your ~/**.ssh** directory.

NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS validated or Modules In Process cryptographic libraries on the **x86_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the ~/**.ssh/id_ed25519.pub** public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the **./openshift-install gather** command.

NOTE

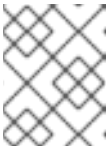
On some distributions, default SSH private key identities such as ~/**.ssh/id_rsa** and ~/**.ssh/id_dsa** are managed automatically.

a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

Example output

```
Agent pid 31874
```



NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

1 Specify the path and file name for your SSH private key, such as **~/.ssh/id_ed25519**

Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

7.5.6. Creating the installation files for Azure Stack Hub

To install OpenShift Container Platform on Microsoft Azure Stack Hub using user-provisioned infrastructure, you must generate the files that the installation program needs to deploy your cluster and modify them so that the cluster creates only the machines that it will use. You manually create the **install-config.yaml** file, and then generate and customize the Kubernetes manifests and Ignition config files. You also have the option to first set up a separate **var** partition during the preparation phases of installation.

7.5.6.1. Manually creating the installation configuration file

Prerequisites

- You have an SSH public key on your local machine to provide to the installation program. The key will be used for SSH authentication onto your cluster nodes for debugging and disaster recovery.
- You have obtained the OpenShift Container Platform installation program and the pull secret for your cluster.

Procedure

1. Create an installation directory to store your required installation assets in:

```
$ mkdir <installation_directory>
```

IMPORTANT

You must create a directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

2. Customize the sample **install-config.yaml** file template that is provided and save it in the **<installation_directory>**.

NOTE

You must name this configuration file **install-config.yaml**.

Make the following modifications for Azure Stack Hub:

a. Set the **replicas** parameter to **0** for the **compute** pool:

```
compute:
- hyperthreading: Enabled
  name: worker
  platform: {}
  replicas: 0 1
```

1 Set to **0**.

The compute machines will be provisioned manually later.

b. Update the **platform.azure** section of the **install-config.yaml** file to configure your Azure Stack Hub configuration:

```
platform:
  azure:
    armEndpoint: <azurestack_arm_endpoint> 1
    baseDomainResourceGroupName: <resource_group> 2
    cloudName: AzureStackCloud 3
    region: <azurestack_region> 4
```

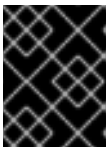
1 Specify the Azure Resource Manager endpoint of your Azure Stack Hub environment, like **https://management.local.azurestack.external**.

2 Specify the name of the resource group that contains the DNS zone for your base domain.

3 Specify the Azure Stack Hub environment, which is used to configure the Azure SDK with the appropriate Azure API endpoints.

4 Specify the name of your Azure Stack Hub region.

3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.



IMPORTANT

The **install-config.yaml** file is consumed during the next step of the installation process. You must back it up now.

7.5.6.2. Sample customized install-config.yaml file for Azure Stack Hub

You can customize the **install-config.yaml** file to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.

IMPORTANT

This sample YAML file is provided for reference only. Use it as a resource to enter parameter values into the installation configuration file that you created manually.

```
apiVersion: v1
baseDomain: example.com
controlPlane: 1
  name: master
  platform:
    azure:
      osDisk:
        diskSizeGB: 1024 2
        diskType: premium_LRS
  replicas: 3
compute: 3
- name: worker
  platform:
    azure:
      osDisk:
        diskSizeGB: 512 4
        diskType: premium_LRS
  replicas: 0
metadata:
  name: test-cluster 5
networking:
  clusterNetwork:
  - cidr: 10.128.0.0/14
    hostPrefix: 23
  machineNetwork:
  - cidr: 10.0.0.0/16
  networkType: OpenShiftSDN
  serviceNetwork:
  - 172.30.0.0/16
platform:
  azure:
    armEndpoint: azurestack_arm_endpoint 6
    baseDomainResourceGroupName: resource_group 7
    region: azure_stack_local_region 8
    resourceGroupName: existing_resource_group 9
    outboundType: Loadbalancer
    cloudName: AzureStackCloud 10
pullSecret: '{"auths": ...}' 11
```

```
fips: false 12
additionalTrustBundle: | 13
  -----BEGIN CERTIFICATE-----
  <MY_TRUSTED_CA_CERT>
  -----END CERTIFICATE-----
sshKey: ssh-ed25519 AAAA... 14
```

1 3 The **controlPlane** section is a single mapping, but the **compute** section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, **-**, and the first line of the **controlPlane** section must not. Only one control plane pool is used.

2 4 You can specify the size of the disk to use in GB. Minimum recommendation for control plane nodes is 1024 GB.

5 Specify the name of the cluster.

6 Specify the Azure Resource Manager endpoint that your Azure Stack Hub operator provides.

7 Specify the name of the resource group that contains the DNS zone for your base domain.

8 Specify the name of your Azure Stack Hub local region.

9 Specify the name of an already existing resource group to install your cluster to. If undefined, a new resource group is created for the cluster.

10 Specify the Azure Stack Hub environment as your target platform.

11 Specify the pull secret required to authenticate your cluster.

12 Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.

IMPORTANT

To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.

13 If your Azure Stack Hub environment uses an internal certificate authority (CA), add the necessary certificate bundle in **.pem** format.

14 You can optionally provide the **sshKey** value that you use to access the machines in your cluster.

NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

7.5.6.3. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.

NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
```

1. A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
2. A proxy URL to use for creating HTTPS connections outside the cluster.
3. A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use * to bypass the proxy for all destinations.
4. If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace that contains one or more additional CA certificates that are required for proxying HTTPS connections. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges these contents with the Red Hat

Enterprise Linux CoreOS (RHCOS) trust bundle, and this config map is referenced in the **trustedCA** field of the **Proxy** object. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.

NOTE

The installation program does not support the proxy **readinessEndpoints** field.

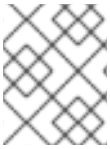
NOTE

If the installer times out, restart and then complete the deployment by using the **wait-for** command of the installer. For example:

```
$ ./openshift-install wait-for install-complete --log-level debug
```

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.

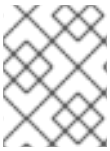


NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

7.5.6.4. Exporting common variables for ARM templates

You must export a common set of variables that are used with the provided Azure Resource Manager (ARM) templates used to assist in completing a user-provided infrastructure install on Microsoft Azure Stack Hub.



NOTE

Specific ARM templates can also require additional exported variables, which are detailed in their related procedures.

Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.

Procedure

1. Export common variables found in the **install-config.yaml** to be used by the provided ARM templates:

```
$ export CLUSTER_NAME=<cluster_name> 1
$ export AZURE_REGION=<azure_region> 2
$ export SSH_KEY=<ssh_key> 3
```

```
$ export BASE_DOMAIN=<base_domain> 4
$ export BASE_DOMAIN_RESOURCE_GROUP=<base_domain_resource_group> 5
```

1. The value of the **.metadata.name** attribute from the **install-config.yaml** file.
2. The region to deploy the cluster into. This is the value of the **.platform.azure.region** attribute from the **install-config.yaml** file.
3. The SSH RSA public key file as a string. You must enclose the SSH key in quotes since it contains spaces. This is the value of the **.sshKey** attribute from the **install-config.yaml** file.
4. The base domain to deploy the cluster to. The base domain corresponds to the DNS zone that you created for your cluster. This is the value of the **.baseDomain** attribute from the **install-config.yaml** file.
5. The resource group where the DNS zone exists. This is the value of the **.platform.azure.baseDomainResourceGroupName** attribute from the **install-config.yaml** file.

For example:

```
$ export CLUSTER_NAME=test-cluster
$ export AZURE_REGION=centralus
$ export SSH_KEY="ssh-rsa xxx/xxx/xxx= user@email.com"
$ export BASE_DOMAIN=example.com
$ export BASE_DOMAIN_RESOURCE_GROUP=ocp-cluster
```

2. Export the kubeadmin credentials:

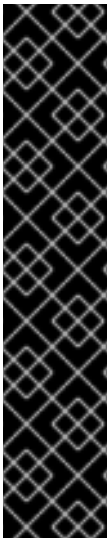
```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

1. For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

7.5.6.5. Creating the Kubernetes manifest and Ignition config files

Because you must modify some cluster definition files and manually start the cluster machines, you must generate the Kubernetes manifest and Ignition config files that the cluster needs to configure the machines.

The installation configuration file transforms into the Kubernetes manifests. The manifests wrap into the Ignition configuration files, which are later used to configure the cluster machines.



IMPORTANT

- The Ignition config files that the OpenShift Container Platform installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

Prerequisites

- You obtained the OpenShift Container Platform installation program.
- You created the **install-config.yaml** installation configuration file.

Procedure

1. Change to the directory that contains the OpenShift Container Platform installation program and generate the Kubernetes manifests for the cluster:

```
$ ./openshift-install create manifests --dir <installation_directory> 1
```

1 For **<installation_directory>**, specify the installation directory that contains the **install-config.yaml** file you created.

2. Remove the Kubernetes manifest files that define the control plane machines:

```
$ rm -f <installation_directory>/openshift/99_openshift-cluster-api_master-machines-*.yaml
```

By removing these files, you prevent the cluster from automatically generating control plane machines.

3. Remove the Kubernetes manifest files that define the worker machines:

```
$ rm -f <installation_directory>/openshift/99_openshift-cluster-api_worker-machineset-*.yaml
```

Because you create and manage the worker machines yourself, you do not need to initialize these machines.

4. Check that the **mastersSchedulable** parameter in the **<installation_directory>/manifests/cluster-scheduler-02-config.yml** Kubernetes manifest file is set to **false**. This setting prevents pods from being scheduled on the control plane machines:

   a. Open the **<installation_directory>/manifests/cluster-scheduler-02-config.yml** file.

   b. Locate the **mastersSchedulable** parameter and ensure that it is set to **false**.

c. Save and exit the file.

5. Optional: If you do not want the Ingress Operator to create DNS records on your behalf, remove the **privateZone** and **publicZone** sections from the **<installation_directory>/manifests/cluster-dns-02-config.yml** DNS configuration file:

```
apiVersion: config.openshift.io/v1
kind: DNS
metadata:
  creationTimestamp: null
  name: cluster
spec:
  baseDomain: example.openshift.com
  privateZone: 1
    id: mycluster-100419-private-zone
  publicZone: 2
    id: example.openshift.com
status: {}
```

1 2 Remove this section completely.

If you do so, you must add ingress DNS records manually in a later step.

6. Optional: If your Azure Stack Hub environment uses an internal certificate authority (CA), you must update the **.spec.trustedCA.name** field in the **<installation_directory>/manifests/cluster-proxy-01-config.yaml** file to use **user-ca-bundle**:

```
...
spec:
  trustedCA:
    name: user-ca-bundle
...
```

Later, you must update your bootstrap ignition to include the CA.

7. When configuring Azure on user-provisioned infrastructure, you must export some common variables defined in the manifest files to use later in the Azure Resource Manager (ARM) templates:

a. Export the infrastructure ID by using the following command:

```
$ export INFRA_ID=<infra_id> 1
```

1 The OpenShift Container Platform cluster has been assigned an identifier (**INFRA_ID**) in the form of **<cluster_name>-<random_string>**. This will be used as the base name for most resources created using the provided ARM templates. This is the value of the **.status.infrastructureName** attribute from the **manifests/cluster-infrastructure-02-config.yml** file.

b. Export the resource group by using the following command:

```
$ export RESOURCE_GROUP=<resource_group> 1
```

1 All resources created in this Azure deployment exists as part of a resource group. The resource group name is also based on the **INFRA_ID**, in the form of **<cluster_name>-**

8. Manually create your cloud credentials.

   a. From the directory that contains the installation program, obtain details of the OpenShift Container Platform release image that your **openshift-install** binary is built to use:

   ```
   $ openshift-install version
   ```

   Example output

   ```
   release image quay.io/openshift-release-dev/ocp-release:4.y.z-x86_64
   ```

   b. Locate all **CredentialsRequest** objects in this release image that target the cloud you are deploying on:

   ```
   $ oc adm release extract quay.io/openshift-release-dev/ocp-release:4.y.z-x86_64 --
   credentials-requests --cloud=azure
   ```

   This command creates a YAML file for each **CredentialsRequest** object.

   Sample CredentialsRequest object

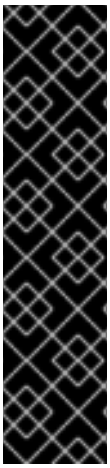
   ```
   apiVersion: cloudcredential.openshift.io/v1
   kind: CredentialsRequest
   metadata:
     labels:
       controller-tools.k8s.io: "1.0"
     name: openshift-image-registry-azure
     namespace: openshift-cloud-credential-operator
   spec:
     secretRef:
       name: installer-cloud-credentials
       namespace: openshift-image-registry
     providerSpec:
       apiVersion: cloudcredential.openshift.io/v1
       kind: AzureProviderSpec
       roleBindings:
       - role: Contributor
   ```

   c. Create YAML files for secrets in the **openshift-install** manifests directory that you generated previously. The secrets must be stored using the namespace and secret name defined in the **spec.secretRef** for each **CredentialsRequest** object. The format for the secret data varies for each cloud provider.

   Sample secrets.yaml file:

   ```
   apiVersion: v1
   kind: Secret
   metadata:
     name: ${secret_name}
     namespace: ${secret_namespace}
   ```

```
stringData:
  azure_subscription_id: ${subscription_id}
  azure_client_id: ${app_id}
  azure_client_secret: ${client_secret}
  azure_tenant_id: ${tenant_id}
  azure_resource_prefix: ${cluster_name}
  azure_resourcegroup: ${resource_group}
  azure_region: ${azure_region}
```



IMPORTANT

The release image includes **CredentialsRequest** objects for Technology Preview features that are enabled by the **TechPreviewNoUpgrade** feature set. You can identify these objects by their use of the **release.openshift.io/feature-gate: TechPreviewNoUpgrade** annotation.

- If you are not using any of these features, do not create secrets for these objects. Creating secrets for Technology Preview features that you are not using can cause the installation to fail.
- If you are using any of these features, you must create secrets for the corresponding objects.

- To find **CredentialsRequest** objects with the **TechPreviewNoUpgrade** annotation, run the following command:

```
$ grep "release.openshift.io/feature-gate" *
```

Example output

```
0000_30_capi-operator_00_credentials-request.yaml:  release.openshift.io/feature-gate:
TechPreviewNoUpgrade
```

a. Create a **cco-configmap.yaml** file in the manifests directory with the Cloud Credential Operator (CCO) disabled:

Sample ConfigMap object

```
apiVersion: v1
kind: ConfigMap
metadata:
name: cloud-credential-operator-config
namespace: openshift-cloud-credential-operator
  annotations:
    release.openshift.io/create-only: "true"
data:
  disabled: "true"
```

1. To create the Ignition configuration files, run the following command from the directory that contains the installation program:

```
$ ./openshift-install create ignition-configs --dir <installation_directory> 1
```

1 For **<installation_directory>**, specify the same installation directory.

Ignition config files are created for the bootstrap, control plane, and compute nodes in the installation directory. The **kubeadmin-password** and **kubeconfig** files are created in the **./<installation_directory>/auth** directory:

```
.
├── auth
│   ├── kubeadmin-password
│   └── kubeconfig
├── bootstrap.ign
├── master.ign
├── metadata.json
└── worker.ign
```

7.5.6.6. Optional: Creating a separate /var partition

It is recommended that disk partitioning for OpenShift Container Platform be left to the installer. However, there are cases where you might want to create separate partitions in a part of the filesystem that you expect to grow.

OpenShift Container Platform supports the addition of a single partition to attach storage to either the **/var** partition or a subdirectory of **/var**. For example:

- **/var/lib/containers**: Holds container-related content that can grow as more images and containers are added to a system.
- **/var/lib/etcd**: Holds data that you might want to keep separate for purposes such as performance optimization of etcd storage.
- **/var**: Holds data that you might want to keep separate for purposes such as auditing.

Storing the contents of a **/var** directory separately makes it easier to grow storage for those areas as needed and reinstall OpenShift Container Platform at a later date and keep that data intact. With this method, you will not have to pull all your containers again, nor will you have to copy massive log files when you update systems.

Because **/var** must be in place before a fresh installation of Red Hat Enterprise Linux CoreOS (RHCOS), the following procedure sets up the separate **/var** partition by creating a machine config manifest that is inserted during the **openshift-install** preparation phases of an OpenShift Container Platform installation.

IMPORTANT

If you follow the steps to create a separate **/var** partition in this procedure, it is not necessary to create the Kubernetes manifest and Ignition config files again as described later in this section.

Procedure

1. Create a directory to hold the OpenShift Container Platform installation files:

```
$ mkdir $HOME/clusterconfig
```

2. Run **openshift-install** to create a set of files in the **manifest** and **openshift** subdirectories. Answer the system questions as you are prompted:

```
$ openshift-install create manifests --dir $HOME/clusterconfig
```

Example output

```
? SSH Public Key ...
INFO Credentials loaded from the "myprofile" profile in file "/home/myuser/.aws/credentials"
INFO Consuming Install Config from target directory
INFO Manifests created in: $HOME/clusterconfig/manifests and
$HOME/clusterconfig/openshift
```

3. Optional: Confirm that the installation program created manifests in the **clusterconfig/openshift** directory:

```
$ ls $HOME/clusterconfig/openshift/
```

Example output

```
99_kubeadmin-password-secret.yaml
99_openshift-cluster-api_master-machines-0.yaml
99_openshift-cluster-api_master-machines-1.yaml
99_openshift-cluster-api_master-machines-2.yaml
...
```

4. Create a Butane config that configures the additional partition. For example, name the file **$HOME/clusterconfig/98-var-partition.bu**, change the disk device name to the name of the storage device on the **worker** systems, and set the storage size as appropriate. This example places the **/var** directory on a separate partition:

```
variant: openshift
version: 4.11.0
metadata:
  labels:
    machineconfiguration.openshift.io/role: worker
  name: 98-var-partition
storage:
  disks:
  - device: /dev/<device_name> 1
    partitions:
    - label: var
      start_mib: <partition_start_offset> 2
      size_mib: <partition_size> 3
  filesystems:
    - device: /dev/disk/by-partlabel/var
      path: /var
      format: xfs
      mount_options: [defaults, prjquota] 4
      with_mount_unit: true
```

1 The storage device name of the disk that you want to partition.

2 When adding a data partition to the boot disk, a minimum value of 25000 MiB (Mebibytes) is recommended. The root file system is automatically resized to fill all available space up

3 The size of the data partition in mebibytes.

4 The **prjquota** mount option must be enabled for filesystems used for container storage.

NOTE

When creating a separate **/var** partition, you cannot use different instance types for worker nodes, if the different instance types do not have the same device name.

5. Create a manifest from the Butane config and save it to the **clusterconfig/openshift** directory. For example, run the following command:

```
$ butane $HOME/clusterconfig/98-var-partition.bu -o $HOME/clusterconfig/openshift/98-var-partition.yaml
```

6. Run **openshift-install** again to create Ignition configs from a set of files in the **manifest** and **openshift** subdirectories:

```
$ openshift-install create ignition-configs --dir $HOME/clusterconfig
$ ls $HOME/clusterconfig/
auth  bootstrap.ign  master.ign  metadata.json  worker.ign
```

Now you can use the Ignition config files as input to the installation procedures to install Red Hat Enterprise Linux CoreOS (RHCOS) systems.

7.5.7. Creating the Azure resource group

You must create a Microsoft Azure resource group. This is used during the installation of your OpenShift Container Platform cluster on Azure Stack Hub.

Prerequisites

- Configure an Azure account.
- Generate the Ignition config files for your cluster.

Procedure

- Create the resource group in a supported Azure region:

```
$ az group create --name ${RESOURCE_GROUP} --location ${AZURE_REGION}
```

7.5.8. Uploading the RHCOS cluster image and bootstrap Ignition config file

The Azure client does not support deployments based on files existing locally. You must copy and store the RHCOS virtual hard disk (VHD) cluster image and bootstrap Ignition config file in a storage container so they are accessible during deployment.

Prerequisites

- Configure an Azure account.
- Generate the Ignition config files for your cluster.

Procedure

1. Create an Azure storage account to store the VHD cluster image:

```
$ az storage account create -g ${RESOURCE_GROUP} --location ${AZURE_REGION} --
name ${CLUSTER_NAME}sa --kind Storage --sku Standard_LRS
```

WARNING

The Azure storage account name must be between 3 and 24 characters in length and use numbers and lower-case letters only. If your **CLUSTER_NAME** variable does not follow these restrictions, you must manually define the Azure storage account name. For more information on Azure storage account name restrictions, see Resolve errors for storage account names in the Azure documentation.

2. Export the storage account key as an environment variable:

```
$ export ACCOUNT_KEY=`az storage account keys list -g ${RESOURCE_GROUP} --
account-name ${CLUSTER_NAME}sa --query "[0].value" -o tsv`
```

3. Export the URL of the RHCOS VHD to an environment variable:

```
$ export COMPRESSED_VHD_URL=$(openshift-install coreos print-stream-json | jq -r
'.architectures.x86_64.artifacts.azurestack.formats."vhd.gz".disk.location')
```

IMPORTANT

The RHCOS images might not change with every release of OpenShift Container Platform. You must specify an image with the highest version that is less than or equal to the OpenShift Container Platform version that you install. Use the image version that matches your OpenShift Container Platform version if it is available.

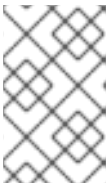
4. Create the storage container for the VHD:

```
$ az storage container create --name vhd --account-name ${CLUSTER_NAME}sa --account-
key ${ACCOUNT_KEY}
```

5. Download the compressed RHCOS VHD file locally:

```
$ curl -O -L ${COMPRESSED_VHD_URL}
```

6. Decompress the VHD file.



NOTE

The decompressed VHD file is approximately 16 GB, so be sure that your host system has 16 GB of free space available. You can delete the VHD file after you upload it.

7. Copy the local VHD to a blob:

```
$ az storage blob upload --account-name ${CLUSTER_NAME}sa --account-key
${ACCOUNT_KEY} -c vhd -n "rhcos.vhd" -f rhcos-<rhcos_version>-azurestack.x86_64.vhd
```

8. Create a blob storage container and upload the generated **bootstrap.ign** file:

```
$ az storage container create --name files --account-name ${CLUSTER_NAME}sa --
account-key ${ACCOUNT_KEY}
```

```
$ az storage blob upload --account-name ${CLUSTER_NAME}sa --account-key
${ACCOUNT_KEY} -c "files" -f "<installation_directory>/bootstrap.ign" -n "bootstrap.ign"
```

7.5.9. Example for creating DNS zones

DNS records are required for clusters that use user-provisioned infrastructure. You should choose the DNS strategy that fits your scenario.

For this example, Azure Stack Hub's datacenter DNS integration is used, so you will create a DNS zone.

NOTE

The DNS zone is not required to exist in the same resource group as the cluster deployment and might already exist in your organization for the desired base domain. If that is the case, you can skip creating the DNS zone; be sure the installation config you generated earlier reflects that scenario.

Prerequisites

- Configure an Azure account.
- Generate the Ignition config files for your cluster.

Procedure

- Create the new DNS zone in the resource group exported in the **BASE_DOMAIN_RESOURCE_GROUP** environment variable:

```
$ az network dns zone create -g ${BASE_DOMAIN_RESOURCE_GROUP} -n
${CLUSTER_NAME}.${BASE_DOMAIN}
```

  You can skip this step if you are using a DNS zone that already exists.

You can learn more about configuring a DNS zone in Azure Stack Hub by visiting that section.

7.5.10. Creating a VNet in Azure Stack Hub

You must create a virtual network (VNet) in Microsoft Azure Stack Hub for your OpenShift Container Platform cluster to use. You can customize the VNet to meet your requirements. One way to create the VNet is to modify the provided Azure Resource Manager (ARM) template.

NOTE

If you do not use the provided ARM template to create your Azure Stack Hub infrastructure, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

Prerequisites

- Configure an Azure account.
- Generate the Ignition config files for your cluster.

Procedure

1. Copy the template from the **ARM template for the VNet**section of this topic and save it as **01_vnet.json** in your cluster's installation directory. This template describes the VNet that your cluster requires.
2. Create the deployment by using the **az** CLI:

```
$ az deployment group create -g ${RESOURCE_GROUP} \
  --template-file "<installation_directory>/01_vnet.json" \
  --parameters baseName="${INFRA_ID}" 1
```

1 The base name to be used in resource names; this is usually the cluster's infrastructure ID.

7.5.10.1. ARM template for the VNet

You can use the following Azure Resource Manager (ARM) template to deploy the VNet that you need for your OpenShift Container Platform cluster:

Example 7.1. 01_vnet.json ARM template

link:https://raw.githubusercontent.com/openshift/installer/release-4.11/upi/azurestack/01_vnet.json[]

7.5.11. Deploying the RHCOS cluster image for the Azure Stack Hub infrastructure

You must use a valid Red Hat Enterprise Linux CoreOS (RHCOS) image for Microsoft Azure Stack Hub for your OpenShift Container Platform nodes.

Prerequisites

- Configure an Azure account.

- Generate the Ignition config files for your cluster.
- Store the RHCOS virtual hard disk (VHD) cluster image in an Azure storage container.
- Store the bootstrap Ignition config file in an Azure storage container.

Procedure

1. Copy the template from the **ARM template for image storage**section of this topic and save it as **02_storage.json** in your cluster's installation directory. This template describes the image storage that your cluster requires.
2. Export the RHCOS VHD blob URL as a variable:

```
$ export VHD_BLOB_URL=`az storage blob url --account-name ${CLUSTER_NAME}sa --
account-key ${ACCOUNT_KEY} -c vhd -n "rhcos.vhd" -o tsv`
```

3. Deploy the cluster image:

```
$ az deployment group create -g ${RESOURCE_GROUP} \
  --template-file "<installation_directory>/02_storage.json" \
  --parameters vhdBlobURL="${VHD_BLOB_URL}" \ 1
  --parameters baseName="${INFRA_ID}" 2
```

1. The blob URL of the RHCOS VHD to be used to create master and worker machines.
2. The base name to be used in resource names; this is usually the cluster's infrastructure ID.

7.5.11.1. ARM template for image storage

You can use the following Azure Resource Manager (ARM) template to deploy the stored Red Hat Enterprise Linux CoreOS (RHCOS) image that you need for your OpenShift Container Platform cluster:

Example 7.2. 02_storage.json ARM template

link:https://raw.githubusercontent.com/openshift/installer/release-4.11/upi/azurestack/02_storage.json[]

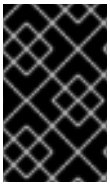
7.5.12. Networking requirements for user-provisioned infrastructure

All the Red Hat Enterprise Linux CoreOS (RHCOS) machines require networking to be configured in **initramfs** during boot to fetch their Ignition config files.

7.5.12.1. Network connectivity requirements

You must configure the network connectivity between machines to allow OpenShift Container Platform cluster components to communicate. Each machine must be able to resolve the hostnames of all other machines in the cluster.

This section provides details about the ports that are required.



IMPORTANT

In connected OpenShift Container Platform environments, all nodes are required to have internet access to pull images for platform containers and provide telemetry data to Red Hat.

Table 7.16. Ports used for all-machine to all-machine communications

Protocol	Port	Description
ICMP	N/A	Network reachability tests
TCP	**1936**	Metrics
	9000-**9999**	Host level services, including the node exporter on ports **9100**-**9101** and the Cluster Version Operator on port**9099**.
	10250-**10259**	The default ports that Kubernetes reserves
	10256	openshift-sdn
UDP	**4789**	VXLAN
	6081	Geneve
	9000-**9999**	Host level services, including the node exporter on ports **9100**-**9101**.
	500	IPsec IKE packets
	4500	IPsec NAT-T packets
TCP/UDP	**30000**-**32767**	Kubernetes node port
ESP	N/A	IPsec Encapsulating Security Payload (ESP)

Table 7.17. Ports used for all-machine to control plane communications

Protocol	Port	Description
TCP	**6443**	Kubernetes API

Table 7.18. Ports used for control plane machine to control plane machine communications

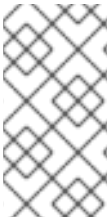
Protocol	Port	Description
TCP	**2379**-**2380**	etcd server and peer ports

7.5.13. Creating networking and load balancing components in Azure Stack Hub

You must configure networking and load balancing in Microsoft Azure Stack Hub for your OpenShift Container Platform cluster to use. One way to create these components is to modify the provided Azure Resource Manager (ARM) template.

Load balancing requires the following DNS records:

- An **api** DNS record for the API public load balancer in the DNS zone.
- An **api-int** DNS record for the API internal load balancer in the DNS zone.



NOTE

If you do not use the provided ARM template to create your Azure Stack Hub infrastructure, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

Prerequisites

- Configure an Azure account.
- Generate the Ignition config files for your cluster.
- Create and configure a VNet and associated subnets in Azure Stack Hub.

Procedure

1. Copy the template from the **ARM template for the network and load balancers** section of this topic and save it as **03_infra.json** in your cluster's installation directory. This template describes the networking and load balancing objects that your cluster requires.
2. Create the deployment by using the **az** CLI:

```
$ az deployment group create -g ${RESOURCE_GROUP} \
  --template-file "<installation_directory>/03_infra.json" \
  --parameters baseName="${INFRA_ID}" 1
```

1 The base name to be used in resource names; this is usually the cluster's infrastructure ID.

3. Create an **api** DNS record and an **api-int** DNS record. When creating the API DNS records, the **${BASE_DOMAIN_RESOURCE_GROUP}** variable must point to the resource group where the DNS zone exists.
   a. Export the following variable:

```
$ export PUBLIC_IP=`az network public-ip list -g ${RESOURCE_GROUP} --query "[?
name=='${INFRA_ID}-master-pip'] | [0].ipAddress" -o tsv`
```

   b. Export the following variable:

```
$ export PRIVATE_IP=`az network lb frontend-ip show -g "$RESOURCE_GROUP" --lb-
name "${INFRA_ID}-internal" -n internal-lb-ip --query "privateIpAddress" -o tsv`
```

c. Create the **api** DNS record in a new DNS zone:

```
$ az network dns record-set a add-record -g ${BASE_DOMAIN_RESOURCE_GROUP} -
z ${CLUSTER_NAME}.${BASE_DOMAIN} -n api -a ${PUBLIC_IP} --ttl 60
```

If you are adding the cluster to an existing DNS zone, you can create the **api** DNS record in it instead:

```
$ az network dns record-set a add-record -g ${BASE_DOMAIN_RESOURCE_GROUP} -
z ${BASE_DOMAIN} -n api.${CLUSTER_NAME} -a ${PUBLIC_IP} --ttl 60
```

d. Create the **api-int** DNS record in a new DNS zone:

```
$ az network dns record-set a add-record -g ${BASE_DOMAIN_RESOURCE_GROUP} -
z "${CLUSTER_NAME}.${BASE_DOMAIN}" -n api-int -a ${PRIVATE_IP} --ttl 60
```

If you are adding the cluster to an existing DNS zone, you can create the **api-int** DNS record in it instead:

```
$ az network dns record-set a add-record -g ${BASE_DOMAIN_RESOURCE_GROUP} -
z ${BASE_DOMAIN} -n api-int.${CLUSTER_NAME} -a ${PRIVATE_IP} --ttl 60
```

7.5.13.1. ARM template for the network and load balancers

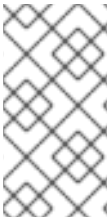
You can use the following Azure Resource Manager (ARM) template to deploy the networking objects and load balancers that you need for your OpenShift Container Platform cluster:

Example 7.3. 03_infra.json ARM template

link:https://raw.githubusercontent.com/openshift/installer/release-4.11/upi/azurestack/03_infra.json[]

7.5.14. Creating the bootstrap machine in Azure Stack Hub

You must create the bootstrap machine in Microsoft Azure Stack Hub to use during OpenShift Container Platform cluster initialization. One way to create this machine is to modify the provided Azure Resource Manager (ARM) template.



NOTE

If you do not use the provided ARM template to create your bootstrap machine, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

Prerequisites

- Configure an Azure account.
- Generate the Ignition config files for your cluster.

- Create and configure a VNet and associated subnets in Azure Stack Hub.
- Create and configure networking and load balancers in Azure Stack Hub.
- Create control plane and compute roles.

Procedure

1. Copy the template from the **ARM template for the bootstrap machine**section of this topic and save it as **04_bootstrap.json** in your cluster's installation directory. This template describes the bootstrap machine that your cluster requires.
2. Export the bootstrap URL variable:

```
$ bootstrap_url_expiry=`date -u -d "10 hours" '+%Y-%m-%dT%H:%MZ'`
```

```
$ export BOOTSTRAP_URL=`az storage blob generate-sas -c 'files' -n 'bootstrap.ign' --https-only --full-uri --permissions r --expiry $bootstrap_url_expiry --account-name ${CLUSTER_NAME}sa --account-key ${ACCOUNT_KEY} -o tsv`
```

3. Export the bootstrap ignition variable:
   a. If your environment uses a public certificate authority (CA), run this command:

```
$ export BOOTSTRAP_IGNITION=`jq -rcnM --arg v "3.2.0" --arg url ${BOOTSTRAP_URL} '{ignition:{version:$v,config:{replace:{source:$url}}}}' | base64 | tr -d '\n'`
```

   b. If your environment uses an internal CA, you must add your PEM encoded bundle to the bootstrap ignition stub so that your bootstrap virtual machine can pull the bootstrap ignition from the storage account. Run the following commands, which assume your CA is in a file called **CA.pem**:

```
$ export CA="data:text/plain;charset=utf-8;base64,$(cat CA.pem |base64 |tr -d '\n')"
```

```
$ export BOOTSTRAP_IGNITION=`jq -rcnM --arg v "3.2.0" --arg url "$BOOTSTRAP_URL" --arg cert "$CA" '{ignition:{version:$v,security:{tls:{certificateAuthorities:[{source:$cert}]}},config:{replace:{source:$url}}}}' | base64 | tr -d '\n'`
```

4. Create the deployment by using the **az** CLI:

```
$ az deployment group create --verbose -g ${RESOURCE_GROUP} \
  --template-file "<installation_directory>/04_bootstrap.json" \
  --parameters bootstrapIgnition="${BOOTSTRAP_IGNITION}" \ 1
  --parameters baseName="${INFRA_ID}" \ 2
  --parameters diagnosticsStorageAccountName="${CLUSTER_NAME}sa" 3
```

1. The bootstrap Ignition content for the bootstrap cluster.
2. The base name to be used in resource names; this is usually the cluster's infrastructure ID.
3. The name of the storage account for your cluster.

7.5.14.1. ARM template for the bootstrap machine

You can use the following Azure Resource Manager (ARM) template to deploy the bootstrap machine that you need for your OpenShift Container Platform cluster:

Example 7.4. 04_bootstrap.json ARM template

link:https://raw.githubusercontent.com/openshift/installer/release-4.11/upi/azurestack/04_bootstrap.json[]

7.5.15. Creating the control plane machines in Azure Stack Hub

You must create the control plane machines in Microsoft Azure Stack Hub for your cluster to use. One way to create these machines is to modify the provided Azure Resource Manager (ARM) template.

If you do not use the provided ARM template to create your control plane machines, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, consider contacting Red Hat support with your installation logs.

Prerequisites

- Configure an Azure account.
- Generate the Ignition config files for your cluster.
- Create and configure a VNet and associated subnets in Azure Stack Hub.
- Create and configure networking and load balancers in Azure Stack Hub.
- Create control plane and compute roles.
- Create the bootstrap machine.

Procedure

1. Copy the template from the **ARM template for control plane machines**section of this topic and save it as **05_masters.json** in your cluster's installation directory. This template describes the control plane machines that your cluster requires.
2. Export the following variable needed by the control plane machine deployment:

```
$ export MASTER_IGNITION=`cat <installation_directory>/master.ign | base64 | tr -d '\n'`
```

3. Create the deployment by using the **az** CLI:

```
$ az deployment group create -g ${RESOURCE_GROUP} \
  --template-file "<installation_directory>/05_masters.json" \
  --parameters masterIgnition="${MASTER_IGNITION}" \ 1
  --parameters baseName="${INFRA_ID}" \ 2
  --parameters diagnosticsStorageAccountName="${CLUSTER_NAME}sa" 3
```

1. The Ignition content for the control plane nodes (also known as the master nodes).

2 The base name to be used in resource names; this is usually the cluster's infrastructure ID.

3 The name of the storage account for your cluster.

7.5.15.1. ARM template for control plane machines

You can use the following Azure Resource Manager (ARM) template to deploy the control plane machines that you need for your OpenShift Container Platform cluster:

Example 7.5. 05_masters.json ARM template

link:https://raw.githubusercontent.com/openshift/installer/release-4.11/upi/azurestack/05_masters.json[]

7.5.16. Wait for bootstrap completion and remove bootstrap resources in Azure Stack Hub

After you create all of the required infrastructure in Microsoft Azure Stack Hub, wait for the bootstrap process to complete on the machines that you provisioned by using the Ignition config files that you generated with the installation program.

Prerequisites

- Configure an Azure account.
- Generate the Ignition config files for your cluster.
- Create and configure a VNet and associated subnets in Azure Stack Hub.
- Create and configure networking and load balancers in Azure Stack Hub.
- Create control plane and compute roles.
- Create the bootstrap machine.
- Create the control plane machines.

Procedure

1. Change to the directory that contains the installation program and run the following command:

```
$ ./openshift-install wait-for bootstrap-complete --dir <installation_directory> \ 1
    --log-level info 2
```

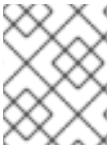
1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

If the command exits without a **FATAL** warning, your production control plane has initialized.

2. Delete the bootstrap resources:

```
$ az network nsg rule delete -g ${RESOURCE_GROUP} --nsg-name ${INFRA_ID}-nsg --
name bootstrap_ssh_in
$ az vm stop -g ${RESOURCE_GROUP} --name ${INFRA_ID}-bootstrap
$ az vm deallocate -g ${RESOURCE_GROUP} --name ${INFRA_ID}-bootstrap
$ az vm delete -g ${RESOURCE_GROUP} --name ${INFRA_ID}-bootstrap --yes
$ az disk delete -g ${RESOURCE_GROUP} --name ${INFRA_ID}-bootstrap_OSDisk --no-
wait --yes
$ az network nic delete -g ${RESOURCE_GROUP} --name ${INFRA_ID}-bootstrap-nic --no-
wait
$ az storage blob delete --account-key ${ACCOUNT_KEY} --account-name
${CLUSTER_NAME}sa --container-name files --name bootstrap.ign
$ az network public-ip delete -g ${RESOURCE_GROUP} --name ${INFRA_ID}-bootstrap-
ssh-pip
```



NOTE

If you do not delete the bootstrap server, installation may not succeed due to API traffic being routed to the bootstrap server.

7.5.17. Creating additional worker machines in Azure Stack Hub

You can create worker machines in Microsoft Azure Stack Hub for your cluster to use by launching individual instances discretely or by automated processes outside the cluster, such as auto scaling groups. You can also take advantage of the built-in cluster scaling mechanisms and the machine API in OpenShift Container Platform.

In this example, you manually launch one instance by using the Azure Resource Manager (ARM) template. Additional instances can be launched by including additional resources of type **06_workers.json** in the file.

If you do not use the provided ARM template to create your control plane machines, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, consider contacting Red Hat support with your installation logs.

Prerequisites

- Configure an Azure account.
- Generate the Ignition config files for your cluster.
- Create and configure a VNet and associated subnets in Azure Stack Hub.
- Create and configure networking and load balancers in Azure Stack Hub.
- Create control plane and compute roles.
- Create the bootstrap machine.
- Create the control plane machines.

Procedure

1. Copy the template from the **ARM template for worker machines** section of this topic and save it as **06_workers.json** in your cluster's installation directory. This template describes the worker machines that your cluster requires.

2. Export the following variable needed by the worker machine deployment:

```
$ export WORKER_IGNITION=`cat <installation_directory>/worker.ign | base64 | tr -d '\n'`
```

3. Create the deployment by using the **az** CLI:

```
$ az deployment group create -g ${RESOURCE_GROUP} \
  --template-file "<installation_directory>/06_workers.json" \
  --parameters workerIgnition="${WORKER_IGNITION}" \ 1
  --parameters baseName="${INFRA_ID}" 2
  --parameters diagnosticsStorageAccountName="${CLUSTER_NAME}sa" 3
```

1. The Ignition content for the worker nodes.
2. The base name to be used in resource names; this is usually the cluster's infrastructure ID.
3. The name of the storage account for your cluster.

7.5.17.1. ARM template for worker machines

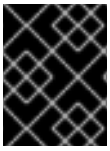
You can use the following Azure Resource Manager (ARM) template to deploy the worker machines that you need for your OpenShift Container Platform cluster:

Example 7.6. 06_workers.json ARM template

```
link:https://raw.githubusercontent.com/openshift/installer/release-
4.11/upi/azurestack/06_workers.json[]
```

7.5.18. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.



IMPORTANT

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.11. Download and install the new version of **oc**.

Installing the OpenShift CLI on Linux

You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.

2. Select the architecture in the **Product Variant** drop-down menu.

3. Select the appropriate version in the **Version** drop-down menu.
4. Click **Download Now** next to the **OpenShift v4.11 Linux Client** entry and save the file.
5. Unpack the archive:

```
$ tar xvf <file>
```

6. Place the **oc** binary in a directory that is on your **PATH**.
   To check your **PATH**, execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.
   To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
C:\> oc <command>
```

Installing the OpenShift CLI on macOS

You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.

3. Click **Download Now** next to the **OpenShift v4.11 macOS Client** entry and save the file.

NOTE

For macOS arm64, choose the **OpenShift v4.11 macOS arm64 Client** entry.

4. Unpack and unzip the archive.

5. Move the **oc** binary to a directory on your PATH.
To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

7.5.19. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

Example output

```
system:admin
```

7.5.20. Approving the certificate signing requests for your machines

When you add machines to a cluster, two pending certificate signing requests (CSRs) are generated for each machine that you added. You must confirm that these CSRs are approved or, if necessary, approve them yourself. The client requests must be approved first, followed by the server requests.

Prerequisites

- You added machines to your cluster.

Procedure

1. Confirm that the cluster recognizes the machines:

```
$ oc get nodes
```

Example output

```
NAME      STATUS    ROLES   AGE  VERSION
master-0  Ready     master  63m  v1.24.0
master-1  Ready     master  63m  v1.24.0
master-2  Ready     master  64m  v1.24.0
```

The output lists all of the machines that you created.

NOTE

The preceding output might not include the compute nodes, also known as worker nodes, until some CSRs are approved.

2. Review the pending CSRs and ensure that you see the client requests with the **Pending** or **Approved** status for each machine that you added to the cluster:

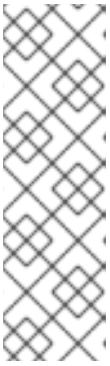
```
$ oc get csr
```

Example output

```
NAME        AGE     REQUESTOR                                                   CONDITION
csr-8b2br   15m     system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper   Pending
csr-8vnps   15m     system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper   Pending
...
```

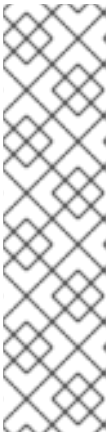
In this example, two machines are joining the cluster. You might see more approved CSRs in the list.

3. If the CSRs were not approved, after all of the pending CSRs for the machines you added are in **Pending** status, approve the CSRs for your cluster machines:



NOTE

Because the CSRs rotate automatically, approve your CSRs within an hour of adding the machines to the cluster. If you do not approve them within an hour, the certificates will rotate, and more than two certificates will be present for each node. You must approve all of these certificates. After the client CSR is approved, the Kubelet creates a secondary CSR for the serving certificate, which requires manual approval. Then, subsequent serving certificate renewal requests are automatically approved by the **machine-approver** if the Kubelet requests a new certificate with identical parameters.



NOTE

For clusters running on platforms that are not machine API enabled, such as bare metal and other user-provisioned infrastructure, you must implement a method of automatically approving the kubelet serving certificate requests (CSRs). If a request is not approved, then the **oc exec**, **oc rsh**, and **oc logs** commands cannot succeed, because a serving certificate is required when the API server connects to the kubelet. Any operation that contacts the Kubelet endpoint requires this certificate approval to be in place. The method must watch for new CSRs, confirm that the CSR was submitted by the **node-bootstrapper** service account in the **system:node** or **system:admin** groups, and confirm the identity of the node.

- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

1 **<csr_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{{"\n"}}
{{end}}{{end}}' | xargs --no-run-if-empty oc adm certificate approve
```

NOTE

Some Operators might not become available until some CSRs are approved.

4. Now that your client requests are approved, you must review the server requests for each machine that you added to the cluster:

```
$ oc get csr
```

Example output

```
NAME        AGE     REQUESTOR                                                   CONDITION
csr-bfd72   5m26s   system:node:ip-10-0-50-126.us-east-2.compute.internal
Pending
csr-c57lv   5m26s   system:node:ip-10-0-95-157.us-east-2.compute.internal
Pending
...
```

5. If the remaining CSRs are not approved, and are in the **Pending** status, approve the CSRs for your cluster machines:

   - To approve them individually, run the following command for each valid CSR:

     ```
     $ oc adm certificate approve <csr_name> 1
     ```

     1 **<csr_name>** is the name of a CSR from the list of current CSRs.

   - To approve all pending CSRs, run the following command:

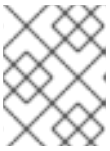
     ```
     $ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{{"\n"}}
     {{end}}{{end}}' | xargs oc adm certificate approve
     ```

6. After all client and server CSRs have been approved, the machines have the **Ready** status. Verify this by running the following command:

   ```
   $ oc get nodes
   ```

   Example output

   ```
   NAME      STATUS    ROLES   AGE  VERSION
   master-0  Ready     master  73m  v1.24.0
   master-1  Ready     master  73m  v1.24.0
   master-2  Ready     master  74m  v1.24.0
   worker-0  Ready     worker  11m  v1.24.0
   worker-1  Ready     worker  11m  v1.24.0
   ```



NOTE

It can take a few minutes after approval of the server CSRs for the machines to transition to the **Ready** status.

Additional information

- For more information on CSRs, see Certificate Signing Requests.

7.5.21. Adding the Ingress DNS records

If you removed the DNS Zone configuration when creating Kubernetes manifests and generating Ignition configs, you must manually create DNS records that point at the Ingress load balancer. You can create either a wildcard ***.apps.{baseDomain}.** or specific records. You can use A, CNAME, and other records per your requirements.

Prerequisites

- You deployed an OpenShift Container Platform cluster on Microsoft Azure Stack Hub by using infrastructure that you provisioned.
- Install the OpenShift CLI (**oc**).
- Install or update the Azure CLI.

Procedure

1. Confirm the Ingress router has created a load balancer and populated the **EXTERNAL-IP** field:

```
$ oc -n openshift-ingress get service router-default
```

Example output

```
NAME            TYPE           CLUSTER-IP      EXTERNAL-IP     PORT(S)                      AGE
router-default  LoadBalancer   172.30.20.10    35.130.120.110
80:32288/TCP,443:31215/TCP   20
```

2. Export the Ingress router IP as a variable:

```
$ export PUBLIC_IP_ROUTER=`oc -n openshift-ingress get service router-default --no-
headers | awk '{print $4}'`
```

3. Add a ***.apps** record to the DNS zone.

   a. If you are adding this cluster to a new DNS zone, run:

```
$ az network dns record-set a add-record -g ${BASE_DOMAIN_RESOURCE_GROUP} -
z ${CLUSTER_NAME}.${BASE_DOMAIN} -n *.apps -a ${PUBLIC_IP_ROUTER} --ttl 300
```

   b. If you are adding this cluster to an already existing DNS zone, run:

```
$ az network dns record-set a add-record -g ${BASE_DOMAIN_RESOURCE_GROUP} -
z ${BASE_DOMAIN} -n *.apps.${CLUSTER_NAME} -a ${PUBLIC_IP_ROUTER} --ttl 300
```

If you prefer to add explicit domains instead of using a wildcard, you can create entries for each of the cluster's current routes:

```
$ oc get --all-namespaces -o jsonpath='{range .items[*]}{range .status.ingress[*]}{.host}{"\n"}{end}
{end}' routes
```

Example output

```
oauth-openshift.apps.cluster.basedomain.com
console-openshift-console.apps.cluster.basedomain.com
downloads-openshift-console.apps.cluster.basedomain.com
alertmanager-main-openshift-monitoring.apps.cluster.basedomain.com
prometheus-k8s-openshift-monitoring.apps.cluster.basedomain.com
```

7.5.22. Completing an Azure Stack Hub installation on user-provisioned infrastructure

After you start the OpenShift Container Platform installation on Microsoft Azure Stack Hub user-provisioned infrastructure, you can monitor the cluster events until the cluster is ready.

Prerequisites

- Deploy the bootstrap machine for an OpenShift Container Platform cluster on user-provisioned Azure Stack Hub infrastructure.
- Install the **oc** CLI and log in.

Procedure

- Complete the cluster installation:

```
$ ./openshift-install --dir <installation_directory> wait-for install-complete 1
```

Example output

```
INFO Waiting up to 30m0s for the cluster to initialize...
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

Additional resources

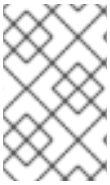
- See About remote health monitoring for more information about the Telemetry service.

7.6. UNINSTALLING A CLUSTER ON AZURE STACK HUB

You can remove a cluster that you deployed to Azure Stack Hub.

7.6.1. Removing a cluster that uses installer-provisioned infrastructure

You can remove a cluster that uses installer-provisioned infrastructure from your cloud.



NOTE

After uninstallation, check your cloud provider for any resources not removed properly, especially with User Provisioned Infrastructure (UPI) clusters. There might be resources that the installer did not create or that the installer is unable to access.

Prerequisites

- You have a copy of the installation program that you used to deploy the cluster.
- You have the files that the installation program generated when you created your cluster.

While you can uninstall the cluster using the copy of the installation program that was used to deploy it, using OpenShift Container Platform version 4.13 or later is recommended.

The removal of service principals is dependent on the Microsoft Azure AD Graph API. Using version 4.13 or later of the installation program ensures that service principals are removed without the need for manual intervention, if and when Microsoft decides to retire the Azure AD Graph API.

Procedure

1. On the computer that you used to install the cluster, go to the directory that contains the installation program, and run the following command:

```
$ ./openshift-install destroy cluster \
--dir <installation_directory> --log-level info 1 2
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2 To view different details, specify **warn**, **debug**, or **error** instead of **info**.

NOTE

You must specify the directory that contains the cluster definition files for your cluster. The installation program requires the **metadata.json** file in this directory to delete the cluster.

2. Optional: Delete the **<installation_directory>** directory and the OpenShift Container Platform installation program.

CHAPTER 8. INSTALLING ON GCP

8.1. PREPARING TO INSTALL ON GCP

8.1.1. Prerequisites

- You reviewed details about the OpenShift Container Platform installation and update processes.
- You read the documentation on selecting a cluster installation method and preparing it for users.

8.1.2. Requirements for installing OpenShift Container Platform on GCP

Before installing OpenShift Container Platform on Google Cloud Platform (GCP), you must create a service account and configure a GCP project. See Configuring a GCP project for details about creating a project, enabling API services, configuring DNS, GCP account limits, and supported GCP regions.

If the cloud identity and access management (IAM) APIs are not accessible in your environment, or if you do not want to store an administrator-level credential secret in the **kube-system** namespace, see Manually creating IAM for GCP for other options.

8.1.3. Choosing a method to install OpenShift Container Platform on GCP

You can install OpenShift Container Platform on installer-provisioned or user-provisioned infrastructure. The default installation type uses installer-provisioned infrastructure, where the installation program provisions the underlying infrastructure for the cluster. You can also install OpenShift Container Platform on infrastructure that you provision. If you do not use infrastructure that the installation program provisions, you must manage and maintain the cluster resources yourself.

See Installation process for more information about installer-provisioned and user-provisioned installation processes.

8.1.3.1. Installing a cluster on installer-provisioned infrastructure

You can install a cluster on GCP infrastructure that is provisioned by the OpenShift Container Platform installation program, by using one of the following methods:

- **Installing a cluster quickly on GCP**: You can install OpenShift Container Platform on GCP infrastructure that is provisioned by the OpenShift Container Platform installation program. You can install a cluster quickly by using the default configuration options.
- **Installing a customized cluster on GCP**: You can install a customized cluster on GCP infrastructure that the installation program provisions. The installation program allows for some customization to be applied at the installation stage. Many other customization options are available post-installation.
- **Installing a cluster on GCP with network customizations**: You can customize your OpenShift Container Platform network configuration during installation, so that your cluster can coexist with your existing IP address allocations and adhere to your network requirements.
- **Installing a cluster on GCP in a restricted network**: You can install OpenShift Container Platform on GCP on installer-provisioned infrastructure by using an internal mirror of the installation release content. You can use this method to install a cluster that does not require an

active internet connection to obtain the software components. While you can install OpenShift Container Platform by using the mirrored content, your cluster still requires internet access to use the GCP APIs.

- **Installing a cluster into an existing Virtual Private Cloud**: You can install OpenShift Container Platform on an existing GCP Virtual Private Cloud (VPC). You can use this installation method if you have constraints set by the guidelines of your company, such as limits on creating new accounts or infrastructure.

- **Installing a private cluster on an existing VPC**: You can install a private cluster on an existing GCP VPC. You can use this method to deploy OpenShift Container Platform on an internal network that is not visible to the internet.

8.1.3.2. Installing a cluster on user-provisioned infrastructure

You can install a cluster on GCP infrastructure that you provision, by using one of the following methods:

- **Installing a cluster on GCP with user-provisioned infrastructure**: You can install OpenShift Container Platform on GCP infrastructure that you provide. You can use the provided Deployment Manager templates to assist with the installation.

- **Installing a cluster with shared VPC on user-provisioned infrastructure in GCP**: You can use the provided Deployment Manager templates to create GCP resources in a shared VPC infrastructure.

- **Installing a cluster on GCP in a restricted network with user-provisioned infrastructure**: You can install OpenShift Container Platform on GCP in a restricted network with user-provisioned infrastructure. By creating an internal mirror of the installation release content, you can install a cluster that does not require an active internet connection to obtain the software components. You can also use this installation method to ensure that your clusters only use container images that satisfy your organizational controls on external content.

8.1.4. Next steps

- Configuring a GCP project

8.2. CONFIGURING A GCP PROJECT

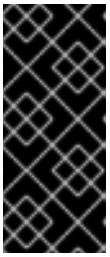
Before you can install OpenShift Container Platform, you must configure a Google Cloud Platform (GCP) project to host it.

8.2.1. Creating a GCP project

To install OpenShift Container Platform, you must create a project in your Google Cloud Platform (GCP) account to host the cluster.

Procedure

- Create a project to host your OpenShift Container Platform cluster. See Creating and Managing Projects in the GCP documentation.



IMPORTANT

Your GCP project must use the Premium Network Service Tier if you are using installer-provisioned infrastructure. The Standard Network Service Tier is not supported for clusters installed using the installation program. The installation program configures internal load balancing for the **api-int.<cluster_name>.<base_domain>** URL; the Premium Tier is required for internal load balancing.

8.2.2. Enabling API services in GCP

Your Google Cloud Platform (GCP) project requires access to several API services to complete OpenShift Container Platform installation.

Prerequisites

- You created a project to host your cluster.

Procedure

- Enable the following required API services in the project that hosts your cluster. You may also enable optional API services which are not required for installation. See Enabling services in the GCP documentation.

Table 8.1. Required API services

API service	Console service name
Compute Engine API	**compute.googleapis.com**
Cloud Resource Manager API	**cloudresourcemanager.googleapis.com**
Google DNS API	**dns.googleapis.com**
IAM Service Account Credentials API	**iamcredentials.googleapis.com**
Identity and Access Management (IAM) API	**iam.googleapis.com**
Service Usage API	**serviceusage.googleapis.com**

Table 8.2. Optional API services

API service	Console service name
Google Cloud APIs	**cloudapis.googleapis.com**
Service Management API	**servicemanagement.googleapis.com**
Google Cloud Storage JSON API	**storage-api.googleapis.com**

API service	Console service name
Cloud Storage	**storage-component.googleapis.com**

8.2.3. Configuring DNS for GCP

To install OpenShift Container Platform, the Google Cloud Platform (GCP) account you use must have a dedicated public hosted zone in the same project that you host the OpenShift Container Platform cluster. This zone must be authoritative for the domain. The DNS service provides cluster DNS resolution and name lookup for external connections to the cluster.

Procedure

1. Identify your domain, or subdomain, and registrar. You can transfer an existing domain and registrar or obtain a new one through GCP or another source.

NOTE

If you purchase a new domain, it can take time for the relevant DNS changes to propagate. For more information about purchasing domains through Google, see Google Domains.

2. Create a public hosted zone for your domain or subdomain in your GCP project. See Creating public zones in the GCP documentation.
   Use an appropriate root domain, such as **openshiftcorp.com**, or subdomain, such as **clusters.openshiftcorp.com**.

3. Extract the new authoritative name servers from the hosted zone records. See Look up your Cloud DNS name servers in the GCP documentation.
   You typically have four name servers.

4. Update the registrar records for the name servers that your domain uses. For example, if you registered your domain to Google Domains, see the following topic in the Google Domains Help: How to switch to custom name servers .

5. If you migrated your root domain to Google Cloud DNS, migrate your DNS records. See Migrating to Cloud DNS in the GCP documentation.

6. If you use a subdomain, follow your company's procedures to add its delegation records to the parent domain. This process might include a request to your company's IT department or the division that controls the root domain and DNS services for your company.

8.2.4. GCP account limits

The OpenShift Container Platform cluster uses a number of Google Cloud Platform (GCP) components, but the default Quotas do not affect your ability to install a default OpenShift Container Platform cluster.

A default cluster, which contains three compute and three control plane machines, uses the following resources. Note that some resources are required only during the bootstrap process and are removed after the cluster deploys.

Table 8.3. GCP resources used in a default cluster

Service	Component	Location	Total resources required	Resources removed after bootstrap
Service account	IAM	Global	5	0
Firewall rules	Compute	Global	11	1
Forwarding rules	Compute	Global	2	0
In-use global IP addresses	Compute	Global	4	1
Health checks	Compute	Global	3	0
Images	Compute	Global	1	0
Networks	Compute	Global	2	0
Static IP addresses	Compute	Region	4	1
Routers	Compute	Global	1	0
Routes	Compute	Global	2	0
Subnetworks	Compute	Global	2	0
Target pools	Compute	Global	3	0
CPUs	Compute	Region	28	4
Persistent disk SSD (GB)	Compute	Region	896	128

NOTE

If any of the quotas are insufficient during installation, the installation program displays an error that states both which quota was exceeded and the region.

Be sure to consider your actual cluster size, planned cluster growth, and any usage from other clusters that are associated with your account. The CPU, static IP addresses, and persistent disk SSD (storage) quotas are the ones that are most likely to be insufficient.

If you plan to deploy your cluster in one of the following regions, you will exceed the maximum storage quota and are likely to exceed the CPU quota limit:

- **asia-east2**
- **asia-northeast2**

- **asia-south1**
- **australia-southeast1**
- **europe-north1**
- **europe-west2**
- **europe-west3**
- **europe-west6**
- **northamerica-northeast1**
- **southamerica-east1**
- **us-west2**

You can increase resource quotas from the GCP console, but you might need to file a support ticket. Be sure to plan your cluster size early so that you can allow time to resolve the support ticket before you install your OpenShift Container Platform cluster.

8.2.5. Creating a service account in GCP

OpenShift Container Platform requires a Google Cloud Platform (GCP) service account that provides authentication and authorization to access data in the Google APIs. If you do not have an existing IAM service account that contains the required roles in your project, you must create one.

Prerequisites

- You created a project to host your cluster.

Procedure

1. Create a service account in the project that you use to host your OpenShift Container Platform cluster. See Creating a service account in the GCP documentation.
2. Grant the service account the appropriate permissions. You can either grant the individual permissions that follow or assign the **Owner** role to it. See Granting roles to a service account for specific resources.

NOTE

While making the service account an owner of the project is the easiest way to gain the required permissions, it means that service account has complete control over the project. You must determine if the risk that comes from offering that power is acceptable.

3. Create the service account key in JSON format. See Creating service account keys in the GCP documentation.
   The service account key is required to create a cluster.

8.2.5.1. Required GCP roles

When you attach the **Owner** role to the service account that you create, you grant that service account

all permissions, including those that are required to install OpenShift Container Platform. If your organization's security policies require a more restrictive set of permissions, you can create a service account with the following permissions. If you deploy your cluster into an existing virtual private cloud (VPC), the service account does not require certain networking permissions, which are noted in the following lists:

Required roles for the installation program

- Compute Admin
- Security Admin
- Service Account Admin
- Service Account Key Admin
- Service Account User
- Storage Admin

Required roles for creating network resources during installation

- DNS Administrator

The roles are applied to the service accounts that the control plane and compute machines use:

Table 8.4. GCP service account permissions

Account	Roles
Control Plane	**roles/compute.instanceAdmin**
	roles/compute.networkAdmin
	roles/compute.securityAdmin
	roles/storage.admin
	roles/iam.serviceAccountUser
Compute	**roles/compute.viewer**
	roles/storage.admin

8.2.5.2. Required GCP permissions for installer-provisioned infrastructure

When you attach the **Owner** role to the service account that you create, you grant that service account all permissions, including those that are required to install OpenShift Container Platform.

If your organization's security policies require a more restrictive set of permissions, you can create custom roles with the necessary permissions. The following permissions are required for the installer-provisioned infrastructure for creating and deleting the OpenShift Container Platform cluster.

-

Example 8.1. Required permissions for creating network resources

- **compute.addresses.create**
- **compute.addresses.createInternal**
- **compute.addresses.delete**
- **compute.addresses.get**
- **compute.addresses.list**
- **compute.addresses.use**
- **compute.addresses.useInternal**
- **compute.firewalls.create**
- **compute.firewalls.delete**
- **compute.firewalls.get**
- **compute.firewalls.list**
- **compute.forwardingRules.create**
- **compute.forwardingRules.get**
- **compute.forwardingRules.list**
- **compute.forwardingRules.setLabels**
- **compute.networks.create**
- **compute.networks.get**
- **compute.networks.list**
- **compute.networks.updatePolicy**
- **compute.routers.create**
- **compute.routers.get**
- **compute.routers.list**
- **compute.routers.update**
- **compute.routes.list**
- **compute.subnetworks.create**
- **compute.subnetworks.get**
- **compute.subnetworks.list**
- **compute.subnetworks.use**

- **compute.subnetworks.useExternalIp**

Example 8.2. Required permissions for creating load balancer resources

- **compute.regionBackendServices.create**
- **compute.regionBackendServices.get**
- **compute.regionBackendServices.list**
- **compute.regionBackendServices.update**
- **compute.regionBackendServices.use**
- **compute.targetPools.addInstance**
- **compute.targetPools.create**
- **compute.targetPools.get**
- **compute.targetPools.list**
- **compute.targetPools.removeInstance**
- **compute.targetPools.use**

Example 8.3. Required permissions for creating DNS resources

- **dns.changes.create**
- **dns.changes.get**
- **dns.managedZones.create**
- **dns.managedZones.get**
- **dns.managedZones.list**
- **dns.networks.bindPrivateDNSZone**
- **dns.resourceRecordSets.create**
- **dns.resourceRecordSets.list**

Example 8.4. Required permissions for creating Service Account resources

- **iam.serviceAccountKeys.create**
- **iam.serviceAccountKeys.delete**
- **iam.serviceAccountKeys.get**
- **iam.serviceAccountKeys.list**

- **iam.serviceAccounts.actAs**
- **iam.serviceAccounts.create**
- **iam.serviceAccounts.delete**
- **iam.serviceAccounts.get**
- **iam.serviceAccounts.list**
- **resourcemanager.projects.get**
- **resourcemanager.projects.getIamPolicy**
- **resourcemanager.projects.setIamPolicy**

Example 8.5. Required permissions for creating compute resources

- **compute.disks.create**
- **compute.disks.get**
- **compute.disks.list**
- **compute.instanceGroups.create**
- **compute.instanceGroups.delete**
- **compute.instanceGroups.get**
- **compute.instanceGroups.list**
- **compute.instanceGroups.update**
- **compute.instanceGroups.use**
- **compute.instances.create**
- **compute.instances.delete**
- **compute.instances.get**
- **compute.instances.list**
- **compute.instances.setLabels**
- **compute.instances.setMetadata**
- **compute.instances.setServiceAccount**
- **compute.instances.setTags**
- **compute.instances.use**
- **compute.machineTypes.get**
- **compute.machineTypes.list**

Example 8.6. Required for creating storage resources

- **storage.buckets.create**
- **storage.buckets.delete**
- **storage.buckets.get**
- **storage.buckets.list**
- **storage.objects.create**
- **storage.objects.delete**
- **storage.objects.get**
- **storage.objects.list**

Example 8.7. Required permissions for creating health check resources

- **compute.healthChecks.create**
- **compute.healthChecks.get**
- **compute.healthChecks.list**
- **compute.healthChecks.useReadOnly**
- **compute.httpHealthChecks.create**
- **compute.httpHealthChecks.get**
- **compute.httpHealthChecks.list**
- **compute.httpHealthChecks.useReadOnly**

Example 8.8. Required permissions to get GCP zone and region related information

- **compute.globalOperations.get**
- **compute.regionOperations.get**
- **compute.regions.list**
- **compute.zoneOperations.get**
- **compute.zones.get**
- **compute.zones.list**

Example 8.9. Required permissions for checking services and quotas

- **monitoring.timeSeries.list**
- **serviceusage.quotas.get**
- **serviceusage.services.list**

Example 8.10. Required IAM permissions for installation

- **iam.roles.get**

Example 8.11. Optional Images permissions for installation

- **compute.images.list**

Example 8.12. Optional permission for running gather bootstrap

- **compute.instances.getSerialPortOutput**

Example 8.13. Required permissions for deleting network resources

- **compute.addresses.delete**
- **compute.addresses.deleteInternal**
- **compute.addresses.list**
- **compute.firewalls.delete**
- **compute.firewalls.list**
- **compute.forwardingRules.delete**
- **compute.forwardingRules.list**
- **compute.networks.delete**
- **compute.networks.list**
- **compute.networks.updatePolicy**
- **compute.routers.delete**
- **compute.routers.list**
- **compute.routes.list**
- **compute.subnetworks.delete**
- **compute.subnetworks.list**

Example 8.14. Required permissions for deleting load balancer resources

- **compute.regionBackendServices.delete**
- **compute.regionBackendServices.list**
- **compute.targetPools.delete**
- **compute.targetPools.list**

Example 8.15. Required permissions for deleting DNS resources

- **dns.changes.create**
- **dns.managedZones.delete**
- **dns.managedZones.get**
- **dns.managedZones.list**
- **dns.resourceRecordSets.delete**
- **dns.resourceRecordSets.list**

Example 8.16. Required permissions for deleting Service Account resources

- **iam.serviceAccounts.delete**
- **iam.serviceAccounts.get**
- **iam.serviceAccounts.list**
- **resourcemanager.projects.getIamPolicy**
- **resourcemanager.projects.setIamPolicy**

Example 8.17. Required permissions for deleting compute resources

- **compute.disks.delete**
- **compute.disks.list**
- **compute.instanceGroups.delete**
- **compute.instanceGroups.list**
- **compute.instances.delete**
- **compute.instances.list**
- **compute.instances.stop**
- **compute.machineTypes.list**

Example 8.18. Required for deleting storage resources

- **storage.buckets.delete**
- **storage.buckets.getIamPolicy**
- **storage.buckets.list**
- **storage.objects.delete**
- **storage.objects.list**

Example 8.19. Required permissions for deleting health check resources

- **compute.healthChecks.delete**
- **compute.healthChecks.list**
- **compute.httpHealthChecks.delete**
- **compute.httpHealthChecks.list**

Example 8.20. Required Images permissions for deletion

- **compute.images.list**

8.2.6. Supported GCP regions

You can deploy an OpenShift Container Platform cluster to the following Google Cloud Platform (GCP) regions:

- **asia-east1** (Changhua County, Taiwan)
- **asia-east2** (Hong Kong)
- **asia-northeast1** (Tokyo, Japan)
- **asia-northeast2** (Osaka, Japan)
- **asia-northeast3** (Seoul, South Korea)
- **asia-south1** (Mumbai, India)
- **asia-south2** (Delhi, India)
- **asia-southeast1** (Jurong West, Singapore)
- **asia-southeast2** (Jakarta, Indonesia)
- **australia-southeast1** (Sydney, Australia)
- **australia-southeast2** (Melbourne, Australia)

- **europe-central2** (Warsaw, Poland)
- **europe-north1** (Hamina, Finland)
- **europe-southwest1** (Madrid, Spain)
- **europe-west1** (St. Ghislain, Belgium)
- **europe-west2** (London, England, UK)
- **europe-west3** (Frankfurt, Germany)
- **europe-west4** (Eemshaven, Netherlands)
- **europe-west6** (Zürich, Switzerland)
- **europe-west8** (Milan, Italy)
- **europe-west9** (Paris, France)
- **europe-west12** (Turin, Italy)
- **northamerica-northeast1** (Montréal, Québec, Canada)
- **northamerica-northeast2** (Toronto, Ontario, Canada)
- **southamerica-east1** (São Paulo, Brazil)
- **southamerica-west1** (Santiago, Chile)
- **us-central1** (Council Bluffs, Iowa, USA)
- **us-east1** (Moncks Corner, South Carolina, USA)
- **us-east4** (Ashburn, Northern Virginia, USA)
- **us-east5** (Columbus, Ohio)
- **us-south1** (Dallas, Texas)
- **us-west1** (The Dalles, Oregon, USA)
- **us-west2** (Los Angeles, California, USA)
- **us-west3** (Salt Lake City, Utah, USA)
- **us-west4** (Las Vegas, Nevada, USA)

NOTE

To determine which machine type instances are available by region and zone, see the Google documentation.

8.2.7. Next steps

- Install an OpenShift Container Platform cluster on GCP. You can install a customized cluster or quickly install a cluster with default options.

8.3. MANUALLY CREATING IAM FOR GCP

In environments where the cloud identity and access management (IAM) APIs are not reachable, or the administrator prefers not to store an administrator-level credential secret in the cluster **kube-system** namespace, you can put the Cloud Credential Operator (CCO) into manual mode before you install the cluster.

8.3.1. Alternatives to storing administrator-level secrets in the kube-system project

The Cloud Credential Operator (CCO) manages cloud provider credentials as Kubernetes custom resource definitions (CRDs). You can configure the CCO to suit the security requirements of your organization by setting different values for the **credentialsMode** parameter in the **install-config.yaml** file.

If you prefer not to store an administrator-level credential secret in the cluster **kube-system** project, you can choose one of the following options when installing OpenShift Container Platform:

- **Use manual mode with GCP Workload Identity**
  You can use the CCO utility (**ccoctl**) to configure the cluster to use manual mode with GCP Workload Identity. When the CCO utility is used to configure the cluster for GCP Workload Identity, it signs service account tokens that provide short-term, limited-privilege security credentials to components.

NOTE

This credentials strategy is supported for only new OpenShift Container Platform clusters and must be configured during installation. You cannot reconfigure an existing cluster that uses a different credentials strategy to use this feature.

- **Manage cloud credentials manually**.
  You can set the **credentialsMode** parameter for the CCO to **Manual** to manage cloud credentials manually. Using manual mode allows each cluster component to have only the permissions it requires, without storing an administrator-level credential in the cluster. You can also use this mode if your environment does not have connectivity to the cloud provider public IAM endpoint. However, you must manually reconcile permissions with new release images for every upgrade. You must also manually supply credentials for every component that requests them.

- **Remove the administrator-level credential secret after installing OpenShift Container Platform with mint mode**:
  If you are using the CCO with the **credentialsMode** parameter set to **Mint**, you can remove or rotate the administrator-level credential after installing OpenShift Container Platform. Mint mode is the default configuration for the CCO. This option requires the presence of the administrator-level credential during an installation. The administrator-level credential is used during the installation to mint other credentials with some permissions granted. The original credential secret is not stored in the cluster permanently.

NOTE

Prior to a non z-stream upgrade, you must reinstate the credential secret with the administrator-level credential. If the credential is not present, the upgrade might be blocked.

Additional resources

- Using manual mode with GCP Workload Identity
- Rotating or removing cloud provider credentials

For a detailed description of all available CCO credential modes and their supported platforms, see About the Cloud Credential Operator.

8.3.2. Manually create IAM

The Cloud Credential Operator (CCO) can be put into manual mode prior to installation in environments where the cloud identity and access management (IAM) APIs are not reachable, or the administrator prefers not to store an administrator-level credential secret in the cluster **kube-system** namespace.

Procedure

1. Change to the directory that contains the installation program and create the **install-config.yaml** file by running the following command:

   ```
   $ openshift-install create install-config --dir <installation_directory>
   ```

   where **<installation_directory>** is the directory in which the installation program creates files.

2. Edit the **install-config.yaml** configuration file so that it contains the **credentialsMode** parameter set to **Manual**.

   Example install-config.yaml configuration file

   ```
   apiVersion: v1
   baseDomain: cluster1.example.com
   credentialsMode: Manual 1
   compute:
   - architecture: amd64
     hyperthreading: Enabled
   ...
   ```

   1 This line is added to set the **credentialsMode** parameter to **Manual**.

3. Generate the manifests by running the following command from the directory that contains the installation program:

   ```
   $ openshift-install create manifests --dir <installation_directory>
   ```

   where **<installation_directory>** is the directory in which the installation program creates files.

4. From the directory that contains the installation program, obtain details of the OpenShift Container Platform release image that your **openshift-install** binary is built to use by running the following command:

   ```
   $ openshift-install version
   ```

   Example output

```
release image quay.io/openshift-release-dev/ocp-release:4.y.z-x86_64
```

5. Locate all **CredentialsRequest** objects in this release image that target the cloud you are deploying on by running the following command:

```
$ oc adm release extract quay.io/openshift-release-dev/ocp-release:4.y.z-x86_64 \
  --credentials-requests \
  --cloud=gcp
```

This command creates a YAML file for each **CredentialsRequest** object.

Sample CredentialsRequest object

```
apiVersion: cloudcredential.openshift.io/v1
kind: CredentialsRequest
metadata:
  name: <component-credentials-request>
  namespace: openshift-cloud-credential-operator
  ...
spec:
  providerSpec:
    apiVersion: cloudcredential.openshift.io/v1
    kind: GCPProviderSpec
    predefinedRoles:
    - roles/storage.admin
    - roles/iam.serviceAccountUser
    skipServiceCheck: true
  ...
```

6. Create YAML files for secrets in the **openshift-install** manifests directory that you generated previously. The secrets must be stored using the namespace and secret name defined in the **spec.secretRef** for each **CredentialsRequest** object.

Sample CredentialsRequest object with secrets

```
apiVersion: cloudcredential.openshift.io/v1
kind: CredentialsRequest
metadata:
  name: <component-credentials-request>
  namespace: openshift-cloud-credential-operator
  ...
spec:
  providerSpec:
    apiVersion: cloudcredential.openshift.io/v1
      ...
  secretRef:
    name: <component-secret>
    namespace: <component-namespace>
  ...
```

Sample Secret object

```
apiVersion: v1
kind: Secret
```

```
metadata:
  name: <component-secret>
  namespace: <component-namespace>
data:
  service_account.json: <base64_encoded_gcp_service_account_file>
```

IMPORTANT

The release image includes **CredentialsRequest** objects for Technology Preview features that are enabled by the **TechPreviewNoUpgrade** feature set. You can identify these objects by their use of the **release.openshift.io/feature-gate: TechPreviewNoUpgrade** annotation.

- If you are not using any of these features, do not create secrets for these objects. Creating secrets for Technology Preview features that you are not using can cause the installation to fail.
- If you are using any of these features, you must create secrets for the corresponding objects.

- To find **CredentialsRequest** objects with the **TechPreviewNoUpgrade** annotation, run the following command:

```
$ grep "release.openshift.io/feature-gate" *
```

Example output

```
0000_30_capi-operator_00_credentials-request.yaml:  release.openshift.io/feature-gate:
TechPreviewNoUpgrade
```

7. From the directory that contains the installation program, proceed with your cluster creation:

```
$ openshift-install create cluster --dir <installation_directory>
```

IMPORTANT

Before upgrading a cluster that uses manually maintained credentials, you must ensure that the CCO is in an upgradeable state.

Additional resources

- Updating a cluster using the web console
- Updating a cluster using the CLI

8.3.3. Mint mode

Mint mode is the default Cloud Credential Operator (CCO) credentials mode for OpenShift Container Platform on platforms that support it. In this mode, the CCO uses the provided administrator-level cloud credential to run the cluster. Mint mode is supported for AWS and GCP.

In mint mode, the **admin** credential is stored in the **kube-system** namespace and then used by the CCO to process the **CredentialsRequest** objects in the cluster and create users for each with specific permissions.

The benefits of mint mode include:

- Each cluster component has only the permissions it requires
- Automatic, on-going reconciliation for cloud credentials, including additional credentials or permissions that might be required for upgrades

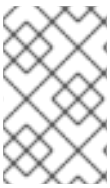
One drawback is that mint mode requires **admin** credential storage in a cluster **kube-system** secret.

8.3.4. Mint mode with removal or rotation of the administrator-level credential

Currently, this mode is only supported on AWS and GCP.

In this mode, a user installs OpenShift Container Platform with an administrator-level credential just like the normal mint mode. However, this process removes the administrator-level credential secret from the cluster post-installation.

The administrator can have the Cloud Credential Operator make its own request for a read-only credential that allows it to verify if all **CredentialsRequest** objects have their required permissions, thus the administrator-level credential is not required unless something needs to be changed. After the associated credential is removed, it can be deleted or deactivated on the underlying cloud, if desired.



NOTE

Prior to a non z-stream upgrade, you must reinstate the credential secret with the administrator-level credential. If the credential is not present, the upgrade might be blocked.

The administrator-level credential is not stored in the cluster permanently.

Following these steps still requires the administrator-level credential in the cluster for brief periods of time. It also requires manually re-instating the secret with administrator-level credentials for each upgrade.

8.3.5. Next steps

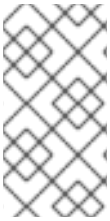
- Install an OpenShift Container Platform cluster:
  - Installing a cluster quickly on GCP with default options on installer-provisioned infrastructure
  - Install a cluster with cloud customizations on installer-provisioned infrastructure
  - Install a cluster with network customizations on installer-provisioned infrastructure

8.4. INSTALLING A CLUSTER QUICKLY ON GCP

In OpenShift Container Platform version 4.11, you can install a cluster on Google Cloud Platform (GCP) that uses the default configuration options.

8.4.1. Prerequisites

- You reviewed details about the OpenShift Container Platform installation and update processes.
- You read the documentation on selecting a cluster installation method and preparing it for users.
- You configured a GCP project to host the cluster.
- If you use a firewall, you configured it to allow the sites that your cluster requires access to.
- If the cloud identity and access management (IAM) APIs are not accessible in your environment, or if you do not want to store an administrator-level credential secret in the **kube-system** namespace, you can manually create and maintain IAM credentials.
- You have determined that the GCP region to which you are installing supports the **N1** machine type. For more information, see the Google documentation. By default, the installation program deploys control plane and compute nodes with the **N1** machine type.



NOTE

If the region to which you are installing does not support the **N1** machine type, you cannot complete the installation using these steps. You must specify a supported machine type in the **install-config.yaml** file before you install the cluster. For more information, see Installing a cluster on GCP with customizations .

8.4.2. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.11, you require access to the internet to install your cluster.

You must have internet access to:

- Access OpenShift Cluster Manager Hybrid Cloud Console to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access Quay.io to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.

IMPORTANT

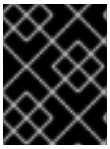
If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

8.4.3. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the ~/**.ssh/authorized_keys** list for the **core** user on each node, which enables password-less authentication.

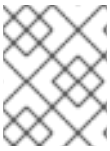
After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The **./openshift-install gather** command also requires the SSH public key to be in place on the cluster nodes.



IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.



NOTE

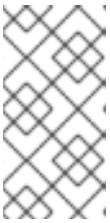
You must use a local key, not one that you configured with platform-specific approaches such as AWS key pairs.

Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N '' -f <path>/<file_name> 1
```

1 Specify the path and file name, such as ~/**.ssh/id_ed25519**, of the new SSH key. If you have an existing key pair, ensure your public key is in the your ~/**.ssh** directory.



NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS validated or Modules In Process cryptographic libraries on the **x86_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the ~/**.ssh/id_ed25519.pub** public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the **./openshift-install gather** command.

NOTE

On some distributions, default SSH private key identities such as ~/**.ssh/id_rsa** and ~/**.ssh/id_dsa** are managed automatically.

a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

Example output

```
Agent pid 31874
```

NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

1 Specify the path and file name for your SSH private key, such as **~/.ssh/id_ed25519**

Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

5. Set the **GOOGLE_APPLICATION_CREDENTIALS** environment variable to the full path to your service account private key file.

```
$ export GOOGLE_APPLICATION_CREDENTIALS="<your_service_account_file>"
```

6. Verify that the credentials were applied.

```
$ gcloud auth list
```

Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

8.4.4. Obtaining the installation program

Before you install OpenShift Container Platform, download the installation file on a local computer.

Prerequisites

- You have a computer that runs Linux or macOS, with 500 MB of local disk space.

Procedure

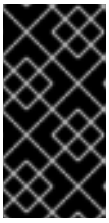
1. Access the Infrastructure Provider page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.

2. Select your infrastructure provider.

3. Navigate to the page for your installation type, download the installation program that corresponds with your host operating system and architecture, and place the file in the directory where you will store the installation configuration files.

IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.



IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

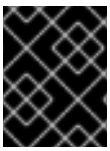
4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation pull secret from the Red Hat OpenShift Cluster Manager . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

8.4.5. Deploying the cluster

You can install OpenShift Container Platform on a compatible cloud platform.



IMPORTANT

You can run the **create cluster** command of the installation program only once, during initial installation.

Prerequisites

- Configure an account with the cloud platform that hosts your cluster.
- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.

Procedure

1. Remove any existing GCP credentials that do not use the service account key for the GCP account that you configured for your cluster and that are stored in the following locations:
   - The **GOOGLE_CREDENTIALS**, **GOOGLE_CLOUD_KEYFILE_JSON**, or **GCLOUD_KEYFILE_JSON** environment variables

- The ~/**.gcp/osServiceAccount.json** file
- The **gcloud cli** default credentials

2. Change to the directory that contains the installation program and initialize the cluster deployment:

```
$ ./openshift-install create cluster --dir <installation_directory> \ 1
    --log-level=info 2
```

1 For **<installation_directory>**, specify the directory name to store the files that the installation program creates.

2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

When specifying the directory:

- Verify that the directory has the **execute** permission. This permission is required to run Terraform binaries under the installation directory.
- Use an empty directory. Some installation assets, such as bootstrap X.509 certificates, have short expiration intervals, therefore you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

3. Provide values at the prompts:

a. Optional: Select an SSH key to use to access your cluster machines.

NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

b. Select **gcp** as the platform to target.

c. If you have not configured the service account key for your GCP account on your computer, you must obtain it from GCP and paste the contents of the file or enter the absolute path to the file.

d. Select the project ID to provision the cluster in. The default value is specified by the service account that you configured.

e. Select the region to deploy the cluster to.

f. Select the base domain to deploy the cluster to. The base domain corresponds to the public DNS zone that you created for your cluster.

g. Enter a descriptive name for your cluster. If you provide a name that is longer than 6 characters, only the first 6 characters will be used in the infrastructure ID that is generated from the cluster name.

h. Paste the pull secret from the Red Hat OpenShift Cluster Manager .

NOTE

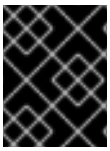
If the cloud provider account that you configured on your host does not have sufficient permissions to deploy the cluster, the installation process stops, and the missing permissions are displayed.

4. Optional: You can reduce the number of permissions for the service account that you used to install the cluster.
   - If you assigned the **Owner** role to your service account, you can remove that role and replace it with the **Viewer** role.
   - If you included the **Service Account Key Admin** role, you can remove it.

Verification

When the cluster deployment completes successfully:

- The terminal displays directions for accessing your cluster, including a link to the web console and credentials for the **kubeadmin** user.
- Credential information also outputs to **<installation_directory>/.openshift_install.log**.



IMPORTANT

Do not delete the installation program or the files that the installation program creates. Both are required to delete the cluster.

Example output

```
...
INFO Install complete!
INFO To access the cluster as the system:admin user when using 'oc', run 'export
KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
INFO Access the OpenShift web-console here: https://console-openshift-
console.apps.mycluster.example.com
INFO Login to the console with user: "kubeadmin", and password: "password"
INFO Time elapsed: 36m22s
```

IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

8.4.6. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.

IMPORTANT

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.11. Download and install the new version of **oc**.

Installing the OpenShift CLI on Linux
You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the architecture in the **Product Variant** drop-down menu.
3. Select the appropriate version in the **Version** drop-down menu.
4. Click **Download Now** next to the **OpenShift v4.11 Linux Client** entry and save the file.
5. Unpack the archive:

```
$ tar xvf <file>
```

6. Place the **oc** binary in a directory that is on your **PATH**.
   To check your **PATH**, execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

-

Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.
   To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

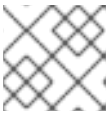
```
C:\> oc <command>
```

Installing the OpenShift CLI on macOS

You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 macOS Client** entry and save the file.



NOTE

For macOS arm64, choose the **OpenShift v4.11 macOS arm64 Client** entry.

4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your PATH.
   To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

8.4.7. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

Example output

```
system:admin
```

Additional resources

- See Accessing the web console for more details about accessing and understanding the OpenShift Container Platform web console.

8.4.8. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.11, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to OpenShift Cluster Manager Hybrid Cloud Console.

After you confirm that your OpenShift Cluster Manager Hybrid Cloud Console inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, use subscription watch to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

Additional resources

- See About remote health monitoring for more information about the Telemetry service

8.4.9. Next steps

- Customize your cluster.
- If necessary, you can opt out of remote health reporting .

8.5. INSTALLING A CLUSTER ON GCP WITH CUSTOMIZATIONS

In OpenShift Container Platform version 4.11, you can install a customized cluster on infrastructure that the installation program provisions on Google Cloud Platform (GCP). To customize the installation, you modify parameters in the **install-config.yaml** file before you install the cluster.

8.5.1. Prerequisites

- You reviewed details about the OpenShift Container Platform installation and update processes.
- You read the documentation on selecting a cluster installation method and preparing it for users.
- You configured a GCP project to host the cluster.
- If you use a firewall, you configured it to allow the sites that your cluster requires access to.
- If the cloud identity and access management (IAM) APIs are not accessible in your environment, or if you do not want to store an administrator-level credential secret in the **kube-system** namespace, you can manually create and maintain IAM credentials.

8.5.2. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.11, you require access to the internet to install your cluster.

You must have internet access to:

- Access OpenShift Cluster Manager Hybrid Cloud Console to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access Quay.io to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.

IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

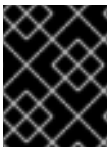
8.5.3. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes

through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the ~/**.ssh/authorized_keys** list for the **core** user on each node, which enables password-less authentication.

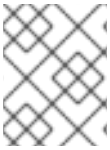
After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The **./openshift-install gather** command also requires the SSH public key to be in place on the cluster nodes.



IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.



NOTE

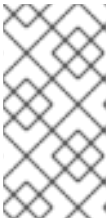
You must use a local key, not one that you configured with platform-specific approaches such as AWS key pairs.

Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N '' -f <path>/<file_name> 1
```

1 Specify the path and file name, such as ~/**.ssh/id_ed25519**, of the new SSH key. If you have an existing key pair, ensure your public key is in the your ~/**.ssh** directory.



NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS validated or Modules In Process cryptographic libraries on the **x86_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

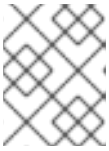
2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the ~/**.ssh/id_ed25519.pub** public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the **./openshift-install gather** command.



NOTE

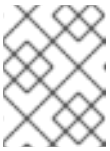
On some distributions, default SSH private key identities such as **~/.ssh/id_rsa** and **~/.ssh/id_dsa** are managed automatically.

a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

Example output

```
Agent pid 31874
```



NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

1 Specify the path and file name for your SSH private key, such as **~/.ssh/id_ed25519**

Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

5. Set the **GOOGLE_APPLICATION_CREDENTIALS** environment variable to the full path to your service account private key file.

```
$ export GOOGLE_APPLICATION_CREDENTIALS="<your_service_account_file>"
```

6. Verify that the credentials were applied.

```
$ gcloud auth list
```

Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

8.5.4. Obtaining the installation program

Before you install OpenShift Container Platform, download the installation file on a local computer.

Prerequisites

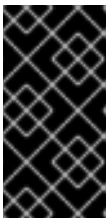
- You have a computer that runs Linux or macOS, with 500 MB of local disk space.

Procedure

1. Access the Infrastructure Provider page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.

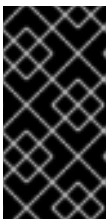
2. Select your infrastructure provider.

3. Navigate to the page for your installation type, download the installation program that corresponds with your host operating system and architecture, and place the file in the directory where you will store the installation configuration files.



IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.



IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation pull secret from the Red Hat OpenShift Cluster Manager . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

8.5.5. Creating the installation configuration file

You can customize the OpenShift Container Platform cluster you install on Google Cloud Platform (GCP).

Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.
- Obtain service principal permissions at the subscription level.

Procedure

1. Create the **install-config.yaml** file.

   a. Change to the directory that contains the installation program and run the following command:

```
$ ./openshift-install create install-config --dir <installation_directory> 1
```

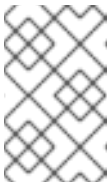
1 For **<installation_directory>**, specify the directory name to store the files that the installation program creates.

When specifying the directory:

- Verify that the directory has the **execute** permission. This permission is required to run Terraform binaries under the installation directory.
- Use an empty directory. Some installation assets, such as bootstrap X.509 certificates, have short expiration intervals, therefore you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

b. At the prompts, provide the configuration details for your cloud:

i. Optional: Select an SSH key to use to access your cluster machines.



NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

ii. Select **gcp** as the platform to target.

iii. If you have not configured the service account key for your GCP account on your computer, you must obtain it from GCP and paste the contents of the file or enter the absolute path to the file.

iv. Select the project ID to provision the cluster in. The default value is specified by the service account that you configured.

v. Select the region to deploy the cluster to.

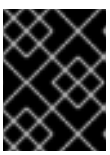
vi. Select the base domain to deploy the cluster to. The base domain corresponds to the public DNS zone that you created for your cluster.

vii. Enter a descriptive name for your cluster.

viii. Paste the pull secret from the Red Hat OpenShift Cluster Manager .

2. Modify the **install-config.yaml** file. You can find more information about the available parameters in the "Installation configuration parameters" section.

3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.



IMPORTANT

The **install-config.yaml** file is consumed during the installation process. If you want to reuse the file, you must back it up now.

8.5.5.1. Installation configuration parameters

Before you deploy an OpenShift Container Platform cluster, you provide parameter values to describe your account on the cloud platform that hosts your cluster and optionally customize your cluster's platform. When you create the **install-config.yaml** installation configuration file, you provide values for the required parameters through the command line. If you customize your cluster, you can modify the **install-config.yaml** file to provide more details about the platform.

NOTE

After installation, you cannot modify these parameters in the **install-config.yaml** file.

8.5.5.1.1. Required configuration parameters

Required installation configuration parameters are described in the following table:

Table 8.5. Required parameters

Parameter	Description	Values
apiVersion	The API version for the **install-config.yaml** content. The current version is **v1**. The installer may also support older API versions.	String
baseDomain	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the **baseDomain** and **metadata.name** parameter values that uses the **<metadata.name>.<baseDomain>** format.	A fully-qualified domain or subdomain name, such as **example.com**.
metadata	Kubernetes resource **ObjectMeta**, from which only the **name** parameter is consumed.	Object
metadata.name	The name of the cluster. DNS records for the cluster are all subdomains of **{{.metadata.name}}.{{.baseDomain}}**.	String of lowercase letters, hyphens (**-**), and periods (**.**), such as **dev**.

Parameter	Description	Values
platform	The configuration for the specific platform upon which to perform the installation: **alibabacloud**, **aws**, **baremetal**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**. For additional information about **platform.<platform>** parameters, consult the table for your specific platform that follows.	Object
pullSecret	Get a pull secret from the Red Hat OpenShift Cluster Manager to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	<pre>{ "auths":{ "cloud.openshift.com":{ "auth":"b3Blb=", "email":"you@example.com" }, "quay.io":{ "auth":"b3Blb=", "email":"you@example.com" } } }</pre>

8.5.5.1.2. Network configuration parameters

You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

Only IPv4 addresses are supported.

NOTE

Globalnet is not supported with Red Hat OpenShift Data Foundation disaster recovery solutions. For regional disaster recovery scenarios, ensure that you use a nonoverlapping range of private IP addresses for the cluster and service networks in each cluster.

Table 8.6. Network parameters

Parameter	Description	Values

Parameter	Description	Values
networking	The configuration for the cluster network.	Object  **NOTE** You cannot modify parameters specified by the **networking** object after installation.
networking.networkType	The cluster network provider Container Network Interface (CNI) cluster network provider to install.	Either **OpenShiftSDN** or **OVNKubernetes**. **OpenShiftSDN** is a CNI provider for all-Linux networks. **OVNKubernetes** is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is **OpenShiftSDN**.
networking.clusterNetwork	The IP address blocks for pods. The default value is **10.128.0.0/14** with a host prefix of **/23**. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: `networking:` `  clusterNetwork:` `  - cidr: 10.128.0.0/14` `    hostPrefix: 23`
networking.clusterNetwork.cidr	Required if you use **networking.clusterNetwork**. An IP address block. An IPv4 network.	An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between **0** and **32**.
networking.clusterNetwork.hostPrefix	The subnet prefix length to assign to each individual node. For example, if **hostPrefix** is set to **23** then each node is assigned a **/23** subnet out of the given **cidr**. A **hostPrefix** value of **23** provides 510 (2^(32 - 23) - 2) pod IP addresses.	A subnet prefix. The default value is **23**.
networking.serviceNetwork	The IP address block for services. The default value is **172.30.0.0/16**. The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.	An array with an IP address block in CIDR format. For example: `networking:` `  serviceNetwork:` `  - 172.30.0.0/16`

Parameter	Description	Values
networking.machineNetwork	The IP address blocks for machines. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: `networking:` `  machineNetwork:` `  - cidr: 10.0.0.0/16`
networking.machineNetwork.cidr	Required if you use **networking.machineNetwork**. An IP address block. The default value is **10.0.0.0/16** for all platforms other than libvirt. For libvirt, the default value is **192.168.126.0/24**.	An IP network block in CIDR notation. For example, **10.0.0.0/16**. **NOTE** Set the **networking.machineNetwork** to match the CIDR that the preferred NIC resides in.

8.5.5.1.3. Optional configuration parameters

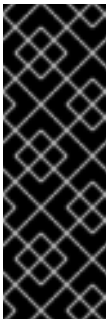
Optional installation configuration parameters are described in the following table:

Table 8.7. Optional parameters

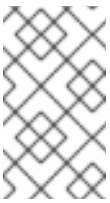
Parameter	Description	Values
additionalTrustBundle	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String
capabilities	Controls the installation of optional core cluster components. You can reduce the footprint of your OpenShift Container Platform cluster by disabling optional components.	String array

Parameter	Description	Values
capabilities.baselineCapabilitySet	Selects an initial set of optional capabilities to enable. Valid values are **None**, **v4.11** and **vCurrent**. **v4.11** enables the **baremetal** Operator, the **marketplace** Operator, and the **openshift-samples** content. **vCurrent** installs the recommended set of capabilities for the current version of OpenShift Container Platform. The default value is **vCurrent**.	String
capabilities.additionalEnabledCapabilities	Extends the set of optional capabilities beyond what you specify in **baselineCapabilitySet**. Valid values are **baremetal**, **marketplace** and **openshift-samples**. You may specify multiple capabilities in this parameter.	String array
cgroupsV2	Enables Linux control groups version 2 (cgroups v2) on specific nodes in your cluster. The OpenShift Container Platform process for enabling cgroups v2 disables all cgroup version 1 controllers and hierarchies. The OpenShift Container Platform cgroups version 2 feature is in Developer Preview and is not supported by Red Hat at this time.	**true**
compute	The configuration for the machines that comprise the compute nodes.	Array of **MachinePool** objects.
compute.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** (the default).	String

Parameter	Description	Values
compute.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  **IMPORTANT** If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
compute.name	Required if you use **compute**. The name of the machine pool.	**worker**
compute.platform	Required if you use **compute**. Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the **controlPlane.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
compute.replicas	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to **2**. The default value is **3**.
controlPlane	The configuration for the machines that comprise the control plane.	Array of **MachinePool** objects.
controlPlane.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** (the default).	String

Parameter	Description	Values
controlPlane.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  **IMPORTANT** If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
controlPlane.name	Required if you use **controlPlane**. The name of the machine pool.	**master**
controlPlane.platform	Required if you use **controlPlane**. Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the **compute.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
controlPlane.replicas	The number of control plane machines to provision.	The only supported value is **3**, which is the default value.

Parameter	Description	Values
credentialsMode	The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported. If you are installing on GCP into a shared virtual private cloud (VPC), **credentialsMode** must be set to **Passthrough**.  **NOTE** Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the *Cloud Credential Operator* entry in the *Cluster Operators reference* content.  **NOTE** If your AWS account has service control policies (SCP) enabled, you must configure the **credentialsMode** parameter to **Mint**, **Passthrough** or **Manual**.	**Mint**, **Passthrough**, **Manual** or an empty string (**""**).

Parameter	Description	Values
fips	Enable or disable FIPS mode. The default is **false** (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.  **IMPORTANT** To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.  **NOTE** If you are using Azure File storage, you cannot enable FIPS mode.	**false** or **true**

Parameter	Description	Values
imageContentSources	Sources and repositories for the release-image content.	Array of objects. Includes a **source** and, optionally, **mirrors**, as described in the following rows of this table.
imageContentSources.source	Required if you use **imageContentSources**. Specify the repository that users refer to, for example, in image pull specifications.	String
imageContentSources.mirrors	Specify one or more repositories that may also contain the same images.	Array of strings
publish	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	**Internal** or **External**. To deploy a private cluster, which cannot be accessed from the internet, set **publish** to **Internal**. The default value is **External**.
sshKey	The SSH key to authenticate access to your cluster machines.  NOTE For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.	For example, **sshKey: ssh-ed25519 AAAA..**.

8.5.5.1.4. Additional Google Cloud Platform (GCP) configuration parameters

Additional GCP configuration parameters are described in the following table:

Table 8.8. Additional GCP parameters

Parameter	Description	Values
platform.gcp.network	The name of the existing VPC that you want to deploy your cluster to.	String.

Parameter	Description	Values
platform.gcp.projectID	The name of the GCP project where the installation program installs the cluster.	String.
platform.gcp.region	The name of the GCP region that hosts your cluster.	Any valid region name, such as **us-central1**.
platform.gcp.controlPlaneSubnet	The name of the existing subnet in your VPC that you want to deploy your control plane machines to.	The subnet name.
platform.gcp.computeSubnet	The name of the existing subnet in your VPC that you want to deploy your compute machines to.	The subnet name.
platform.gcp.licenses	A list of license URLs that must be applied to the compute images.  **IMPORTANT** The **licenses** parameter is a deprecated field and nested virtualization is enabled by default. It is not recommended to use this field.	Any license available with the license API, such as the license to enable nested virtualization. You cannot use this parameter with a mechanism that generates pre-built images. Using a license URL forces the installer to copy the source image before use.
platform.gcp.defaultMachinePlatform.osDisk.diskSizeGB	The size of the disk in gigabytes (GB).	Any size between 16 GB and 65536 GB.

Parameter	Description	Values
platform.gcp.defaultMachinePlatform.osDisk.diskType	The type of disk.	Either the default **pd-ssd** or the **pd-standard** disk type. The control plane nodes must be the **pd-ssd** disk type. The worker nodes can be either type.
platform.gcp.defaultMachinePlatform.osImage.project	Optional. By default, the installation program downloads and installs the RHCOS image that is used to boot control plane and compute machines. You can override the default behavior by specifying the location of a custom RHCOS image for the installation program to use for both types of machines.	String. The name of GCP project where the image is located.
platform.gcp.defaultMachinePlatform.osImage.name	The name of the custom RHCOS image for the installation program to use to boot control plane and compute machines. If you use **platform.gcp.defaultMachinePlatform.osImage.project**, this field is required.	String. The name of the RHCOS image.
platform.gcp.defaultMachinePlatform.type	The GCP machine type.	The GCP machine type.
platform.gcp.defaultMachinePlatform.zones	The availability zones where the installation program creates machines for the specified MachinePool.	A list of valid GCP availability zones, such as **us-central1-a**, in a YAML sequence.

Parameter	Description	Values
controlPlane.platform.gcp.osDisk.encryptionKey.kmsKey.name	The name of the customer managed encryption key to be used for control plane machine disk encryption.	The encryption key name.
controlPlane.platform.gcp.osDisk.encryptionKey.kmsKey.keyRing	For control plane machines, the name of the KMS key ring to which the KMS key belongs.	The KMS key ring name.
controlPlane.platform.gcp.osDisk.encryptionKey.kmsKey.location	For control plane machines, the GCP location in which the key ring exists. For more information on KMS locations, see Google's documentation on Cloud KMS locations.	The GCP location for the key ring.
controlPlane.platform.gcp.osDisk.encryptionKey.kmsKey.projectID	For control plane machines, the ID of the project in which the KMS key ring exists. This value defaults to the VM project ID if not set.	The GCP project ID.

Parameter	Description	Values
controlPlane.platform.gcp.osImage.project	Optional. By default, the installation program downloads and installs the Red Hat Enterprise Linux CoreOS (RHCOS) image that is used to boot control plane machines. You can override the default behavior by specifying the location of a custom RHCOS image for the installation program to use for control plane machines only.	String. The name of GCP project where the image is located.
controlPlane.platform.gcp.osImage.name	The name of the custom RHCOS image for the installation program to use to boot control plane machines. If you use **controlPlane.platform.gcp.osImage.project**, this field is required.	String. The name of the RHCOS image.
compute.platform.gcp.osDisk.encryptionKey.kmsKey.name	The name of the customer managed encryption key to be used for compute machine disk encryption.	The encryption key name.
compute.platform.gcp.osDisk.encryptionKey.kmsKey.keyRing	For compute machines, the name of the KMS key ring to which the KMS key belongs.	The KMS key ring name.

Parameter	Description	Values
compute.platform.gcp.osDisk.encryptionKey.kmsKey.location	For compute machines, the GCP location in which the key ring exists. For more information on KMS locations, see Google's documentation on Cloud KMS locations.	The GCP location for the key ring.
compute.platform.gcp.osDisk.encryptionKey.kmsKey.projectID	For compute machines, the ID of the project in which the KMS key ring exists. This value defaults to the VM project ID if not set.	The GCP project ID.
compute.platform.gcp.osImage.project	Optional. By default, the installation program downloads and installs the RHCOS image that is used to boot compute machines. You can override the default behavior by specifying the location of a custom RHCOS image for the installation program to use for compute machines only.	String. The name of GCP project where the image is located.
compute.platform.gcp.osImage.name	The name of the custom RHCOS image for the installation program to use to boot compute machines. If you use **compute.platform.gcp.osImage.project**, this field is required.	String. The name of the RHCOS image.

8.5.5.2. Minimum resource requirements for cluster installation

Each cluster machine must meet the following minimum requirements:

Table 8.9. Minimum resource requirements

Machine	Operating System	vCPU [1]	Virtual RAM	Storage	IOPS [2]
Bootstrap	RHCOS	4	16 GB	100 GB	300
Control plane	RHCOS	4	16 GB	100 GB	300
Compute	RHCOS, RHEL 8.6 and later [3]	2	8 GB	100 GB	300

1. One vCPU is equivalent to one physical core when simultaneous multithreading (SMT), or hyperthreading, is not enabled. When enabled, use the following formula to calculate the corresponding ratio: (threads per core × cores) × sockets = vCPUs.

2. OpenShift Container Platform and Kubernetes are sensitive to disk performance, and faster storage is recommended, particularly for etcd on the control plane nodes which require a 10 ms p99 fsync duration. Note that on many cloud platforms, storage size and IOPS scale together, so you might need to over-allocate storage volume to obtain sufficient performance.

3. As with all user-provisioned installations, if you choose to use RHEL compute machines in your cluster, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks. Use of RHEL 7 compute machines is deprecated and has been removed in OpenShift Container Platform 4.10 and later.

If an instance type for your platform meets the minimum requirements for cluster machines, it is supported to use in OpenShift Container Platform.

Additional resources

- Optimizing storage

8.5.5.3. Tested instance types for GCP

The following Google Cloud Platform instance types have been tested with OpenShift Container Platform.

Example 8.21. Machine series

- **C2**
- **C2D**
- **C3**
- **E2**
- **M1**
- **N1**
- **N2**

- **N2D**
- **Tau T2D**

8.5.5.4. Using custom machine types

Using a custom machine type to install a OpenShift Container Platform cluster is supported.

Consider the following when using a custom machine type:

- Similar to predefined instance types, custom machine types must meet the minimum resource requirements for control plane and compute machines. For more information, see "Minimum resource requirements for cluster installation".
- The name of the custom machine type must adhere to the following syntax: **custom-<number_of_cpus>-<amount_of_memory_in_mb>**

  For example, **custom-6-20480**.

As part of the installation process, you specify the custom machine type in the **install-config.yaml** file.

Sample install-config.yaml file with a custom machine type

```
compute:
- architecture: amd64
  hyperthreading: Enabled
  name: worker
  platform:
    gcp:
      type: custom-6-20480
  replicas: 2
controlPlane:
  architecture: amd64
  hyperthreading: Enabled
  name: master
  platform:
    gcp:
      type: custom-6-20480
  replicas: 3
```

8.5.5.5. Sample customized install-config.yaml file for GCP

You can customize the **install-config.yaml** file to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.

IMPORTANT

This sample YAML file is provided for reference only. You must obtain your **install-config.yaml** file by using the installation program and modify it.

```
apiVersion: v1
baseDomain: example.com (1)
controlPlane: (2) (3)
```

```
  hyperthreading: Enabled 4
  name: master
  platform:
    gcp:
      type: n2-standard-4
      zones:
      - us-central1-a
      - us-central1-c
      osDisk:
        diskType: pd-ssd
        diskSizeGB: 1024
        encryptionKey: 5
          kmsKey:
            name: worker-key
            keyRing: test-machine-keys
            location: global
            projectID: project-id
        osImage: 6
          project: example-project-name
          name: example-image-name
  replicas: 3
compute: 7 8
- hyperthreading: Enabled 9
  name: worker
  platform:
    gcp:
      type: n2-standard-4
      zones:
      - us-central1-a
      - us-central1-c
      osDisk:
        diskType: pd-standard
        diskSizeGB: 128
        encryptionKey: 10
          kmsKey:
            name: worker-key
            keyRing: test-machine-keys
            location: global
            projectID: project-id
        osImage: 11
          project: example-project-name
          name: example-image-name
  replicas: 3
metadata:
  name: test-cluster 12
networking:
  clusterNetwork:
  - cidr: 10.128.0.0/14
    hostPrefix: 23
  machineNetwork:
  - cidr: 10.0.0.0/16
  networkType: OpenShiftSDN
  serviceNetwork:
  - 172.30.0.0/16
platform:
```

```
  gcp:
    projectID: openshift-production 13
    region: us-central1 14
    defaultMachinePlatform:
      osImage: 15
        project: example-project-name
        name: example-image-name
pullSecret: '{"auths": ...}' 16
fips: false 17
sshKey: ssh-ed25519 AAAA... 18
```

1 12 13 14 16 Required. The installation program prompts you for this value.

2 7 If you do not provide these parameters and values, the installation program provides the default value.

3 8 The **controlPlane** section is a single mapping, but the **compute** section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, **-**, and the first line of the **controlPlane** section must not. Only one control plane pool is used.

4 9 Whether to enable or disable simultaneous multithreading, or **hyperthreading**. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores. You can disable it by setting the parameter value to **Disabled**. If you disable simultaneous multithreading in some cluster machines, you must disable it in all cluster machines.

IMPORTANT

If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance. Use larger machine types, such as **n1-standard-8**, for your machines if you disable simultaneous multithreading.

5 10 Optional: The custom encryption key section to encrypt both virtual machines and persistent volumes. Your default compute service account must have the permissions granted to use your KMS key and have the correct IAM role assigned. The default service account name follows the **service-<project_number>@compute-system.iam.gserviceaccount.com** pattern. For more information on granting the correct permissions for your service account, see "Machine management" → "Creating machine sets" → "Creating a machine set on GCP".

6 11 15 Optional: A custom Red Hat Enterprise Linux CoreOS (RHCOS) image for the installation program to use to boot control plane and compute machines. The **project** and **name** parameters under **platform.gcp.defaultMachinePlatform.osImage** apply to both control plane and compute machines. If the **project** and **name** parameters under **controlPlane.platform.gcp.osImage** or **compute.platform.gcp.osImage** are set, they override the **platform.gcp.defaultMachinePlatform.osImage** parameters.

17 Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.

IMPORTANT

To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.

18 You can optionally provide the **sshKey** value that you use to access the machines in your cluster.

NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

Additional resources

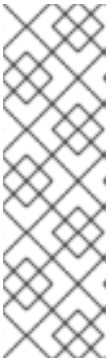
- Enabling customer-managed encryption keys for a machine set

8.5.5.6. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.



NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

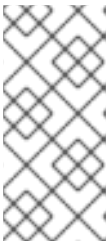
```
apiVersion: v1
baseDomain: my.domain.com
```

```
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
```

1. A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
2. A proxy URL to use for creating HTTPS connections outside the cluster.
3. A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use * to bypass the proxy for all destinations.
4. If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace that contains one or more additional CA certificates that are required for proxying HTTPS connections. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges these contents with the Red Hat Enterprise Linux CoreOS (RHCOS) trust bundle, and this config map is referenced in the **trustedCA** field of the **Proxy** object. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.

NOTE

The installation program does not support the proxy **readinessEndpoints** field.



NOTE

If the installer times out, restart and then complete the deployment by using the **wait-for** command of the installer. For example:

```
$ ./openshift-install wait-for install-complete --log-level debug
```

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.

NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

8.5.6. Using the GCP Marketplace offering

Using the GCP Marketplace offering lets you deploy an OpenShift Container Platform cluster, which is billed on pay-per-use basis (hourly, per core) through GCP, while still being supported directly by Red Hat.

By default, the installation program downloads and installs the Red Hat Enterprise Linux CoreOS (RHCOS) image that is used to deploy compute machines. To deploy an OpenShift Container Platform cluster using an RHCOS image from the GCP Marketplace, override the default behavior by modifying the **install-config.yaml** file to reference the location of GCP Marketplace offer.

Prerequisites

- You have an existing **install-config.yaml** file.

Procedure

1. Edit the **compute.platform.gcp.osImage** parameters to specify the location of the GCP Marketplace image:
   - Set the **project** parameter to **redhat-marketplace-public**.
   - Set the **name** parameter to one of the following offerings:

     OpenShift Container Platform

     redhat-coreos-ocp-48-x86-64-202210040145

     OpenShift Platform Plus

     redhat-coreos-opp-48-x86-64-202206140145

     OpenShift Kubernetes Engine

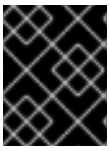
     redhat-coreos-oke-48-x86-64-202206140145
2. Save the file and reference it when deploying the cluster.

Sample install-config.yaml file that specifies a GCP Marketplace image for compute machines

```
apiVersion: v1
baseDomain: example.com
controlPlane:
# ...
compute:
  platform:
    gcp:
      osImage:
        project: redhat-marketplace-public
        name: redhat-coreos-ocp-48-x86-64-202210040145
# ...
```

8.5.7. Deploying the cluster

You can install OpenShift Container Platform on a compatible cloud platform.



IMPORTANT

You can run the **create cluster** command of the installation program only once, during initial installation.

Prerequisites

- Configure an account with the cloud platform that hosts your cluster.
- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.

Procedure

1. Remove any existing GCP credentials that do not use the service account key for the GCP account that you configured for your cluster and that are stored in the following locations:
   - The **GOOGLE_CREDENTIALS**, **GOOGLE_CLOUD_KEYFILE_JSON**, or **GCLOUD_KEYFILE_JSON** environment variables
   - The ~/**.gcp/osServiceAccount.json** file
   - The **gcloud cli** default credentials
2. Change to the directory that contains the installation program and initialize the cluster deployment:

```
$ ./openshift-install create cluster --dir <installation_directory> \ 1
    --log-level=info 2
```

1 For **<installation_directory>**, specify the location of your customized **./install-config.yaml** file.

2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

NOTE

If the cloud provider account that you configured on your host does not have sufficient permissions to deploy the cluster, the installation process stops, and the missing permissions are displayed.

3. Optional: You can reduce the number of permissions for the service account that you used to install the cluster.
   - If you assigned the **Owner** role to your service account, you can remove that role and replace it with the **Viewer** role.
   - If you included the **Service Account Key Admin** role, you can remove it.

Verification

When the cluster deployment completes successfully:

- The terminal displays directions for accessing your cluster, including a link to the web console and credentials for the **kubeadmin** user.

- Credential information also outputs to **<installation_directory>/.openshift_install.log**.

IMPORTANT

Do not delete the installation program or the files that the installation program creates. Both are required to delete the cluster.

Example output

```
...
INFO Install complete!
INFO To access the cluster as the system:admin user when using 'oc', run 'export
KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
INFO Access the OpenShift web-console here: https://console-openshift-
console.apps.mycluster.example.com
INFO Login to the console with user: "kubeadmin", and password: "password"
INFO Time elapsed: 36m22s
```

IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

8.5.8. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.

IMPORTANT

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.11. Download and install the new version of **oc**.

Installing the OpenShift CLI on Linux

You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the architecture in the **Product Variant** drop-down menu.

3. Select the appropriate version in the **Version** drop-down menu.
4. Click **Download Now** next to the **OpenShift v4.11 Linux Client** entry and save the file.
5. Unpack the archive:

```
$ tar xvf <file>
```

6. Place the **oc** binary in a directory that is on your **PATH**.
   To check your **PATH**, execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.
   To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
C:\> oc <command>
```

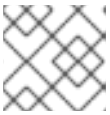
Installing the OpenShift CLI on macOS

You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.

3. Click **Download Now** next to the **OpenShift v4.11 macOS Client** entry and save the file.



NOTE

For macOS arm64, choose the **OpenShift v4.11 macOS arm64 Client** entry.

4. Unpack and unzip the archive.

5. Move the **oc** binary to a directory on your PATH.
To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

8.5.9. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

Example output

```
system:admin
```

Additional resources

- See Accessing the web console for more details about accessing and understanding the OpenShift Container Platform web console.

8.5.10. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.11, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to OpenShift Cluster Manager Hybrid Cloud Console.

After you confirm that your OpenShift Cluster Manager Hybrid Cloud Console inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, use subscription watch to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

Additional resources

- See About remote health monitoring for more information about the Telemetry service

8.5.11. Next steps

- Customize your cluster.
- If necessary, you can opt out of remote health reporting .

8.6. INSTALLING A CLUSTER ON GCP WITH NETWORK CUSTOMIZATIONS

In OpenShift Container Platform version 4.11, you can install a cluster with a customized network configuration on infrastructure that the installation program provisions on Google Cloud Platform (GCP). By customizing your network configuration, your cluster can coexist with existing IP address allocations in your environment and integrate with existing MTU and VXLAN configurations. To customize the installation, you modify parameters in the **install-config.yaml** file before you install the cluster.

You must set most of the network configuration parameters during installation, and you can modify only **kubeProxy** configuration parameters in a running cluster.

8.6.1. Prerequisites

- You reviewed details about the OpenShift Container Platform installation and update processes.
- You read the documentation on selecting a cluster installation method and preparing it for users.
- You configured a GCP project to host the cluster.
- If you use a firewall, you configured it to allow the sites that your cluster requires access to.
- If the cloud identity and access management (IAM) APIs are not accessible in your environment, or if you do not want to store an administrator-level credential secret in the **kube-system** namespace, you can manually create and maintain IAM credentials.

8.6.2. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.11, you require access to the internet to install your cluster.

You must have internet access to:

- Access OpenShift Cluster Manager Hybrid Cloud Console to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access Quay.io to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.

IMPORTANT

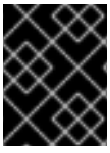
If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

8.6.3. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the **~/.ssh/authorized_keys** list for the **core** user on each node, which enables password-less authentication.

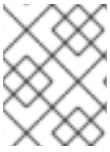
After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The **./openshift-install gather** command also requires the SSH public key to be in place on the cluster nodes.



IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.



NOTE

You must use a local key, not one that you configured with platform-specific approaches such as AWS key pairs.

Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N '' -f <path>/<file_name> 1
```

1 Specify the path and file name, such as ~/**.ssh/id_ed25519**, of the new SSH key. If you have an existing key pair, ensure your public key is in the your ~/**.ssh** directory.

NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS validated or Modules In Process cryptographic libraries on the **x86_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

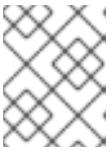
2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the ~/**.ssh/id_ed25519.pub** public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the **./openshift-install gather** command.



NOTE

On some distributions, default SSH private key identities such as ~/**.ssh/id_rsa** and ~/**.ssh/id_dsa** are managed automatically.

a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

Example output

```
Agent pid 31874
```

NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

1 Specify the path and file name for your SSH private key, such as ~/**.ssh/id_ed25519**

Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

5. Set the **GOOGLE_APPLICATION_CREDENTIALS** environment variable to the full path to your service account private key file.

```
$ export GOOGLE_APPLICATION_CREDENTIALS="<your_service_account_file>"
```

6. Verify that the credentials were applied.

```
$ gcloud auth list
```

Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

8.6.4. Obtaining the installation program

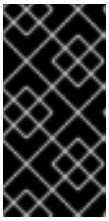
Before you install OpenShift Container Platform, download the installation file on a local computer.

Prerequisites

- You have a computer that runs Linux or macOS, with 500 MB of local disk space.

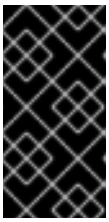
Procedure

1. Access the Infrastructure Provider page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program that corresponds with your host operating system and architecture, and place the file in the directory where you will store the installation configuration files.



IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.



IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation pull secret from the Red Hat OpenShift Cluster Manager . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

8.6.5. Creating the installation configuration file

You can customize the OpenShift Container Platform cluster you install on Google Cloud Platform (GCP).

Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.
- Obtain service principal permissions at the subscription level.

Procedure

1. Create the **install-config.yaml** file.
   a. Change to the directory that contains the installation program and run the following command:

```
$ ./openshift-install create install-config --dir <installation_directory> 1
```

   1 For **<installation_directory>**, specify the directory name to store the files that the installation program creates.

   When specifying the directory:

   - Verify that the directory has the **execute** permission. This permission is required to run Terraform binaries under the installation directory.
   - Use an empty directory. Some installation assets, such as bootstrap X.509 certificates, have short expiration intervals, therefore you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

   b. At the prompts, provide the configuration details for your cloud:
      i. Optional: Select an SSH key to use to access your cluster machines.

NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

ii. Select **gcp** as the platform to target.

iii. If you have not configured the service account key for your GCP account on your computer, you must obtain it from GCP and paste the contents of the file or enter the absolute path to the file.

iv. Select the project ID to provision the cluster in. The default value is specified by the service account that you configured.

v. Select the region to deploy the cluster to.

vi. Select the base domain to deploy the cluster to. The base domain corresponds to the public DNS zone that you created for your cluster.

vii. Enter a descriptive name for your cluster.

viii. Paste the pull secret from the Red Hat OpenShift Cluster Manager .

2. Modify the **install-config.yaml** file. You can find more information about the available parameters in the "Installation configuration parameters" section.

3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.

IMPORTANT

The **install-config.yaml** file is consumed during the installation process. If you want to reuse the file, you must back it up now.

8.6.5.1. Installation configuration parameters

Before you deploy an OpenShift Container Platform cluster, you provide parameter values to describe your account on the cloud platform that hosts your cluster and optionally customize your cluster's platform. When you create the **install-config.yaml** installation configuration file, you provide values for the required parameters through the command line. If you customize your cluster, you can modify the **install-config.yaml** file to provide more details about the platform.

NOTE

After installation, you cannot modify these parameters in the **install-config.yaml** file.

8.6.5.1.1. Required configuration parameters

Required installation configuration parameters are described in the following table:

Table 8.10. Required parameters

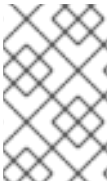
Parameter	Description	Values
apiVersion	The API version for the **install-config.yaml** content. The current version is **v1**. The installer may also support older API versions.	String
baseDomain	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the **baseDomain** and **metadata.name** parameter values that uses the **<metadata.name>.<baseDomain>** format.	A fully-qualified domain or subdomain name, such as **example.com**.
metadata	Kubernetes resource **ObjectMeta**, from which only the **name** parameter is consumed.	Object
metadata.name	The name of the cluster. DNS records for the cluster are all subdomains of **{{.metadata.name}}.{{.baseDomain}}**.	String of lowercase letters, hyphens (**-**), and periods (**.**), such as **dev**.
platform	The configuration for the specific platform upon which to perform the installation: **alibabacloud**, **aws**, **baremetal**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**. For additional information about **platform.<platform>** parameters, consult the table for your specific platform that follows.	Object

Parameter	Description	Values
pullSecret	Get a pull secret from the Red Hat OpenShift Cluster Manager to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	<pre>{ "auths":{ "cloud.openshift.com":{ "auth":"b3Blb=", "email":"you@example.com" }, "quay.io":{ "auth":"b3Blb=", "email":"you@example.com" } } }</pre>

8.6.5.1.2. Network configuration parameters

You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

Only IPv4 addresses are supported.



NOTE

Globalnet is not supported with Red Hat OpenShift Data Foundation disaster recovery solutions. For regional disaster recovery scenarios, ensure that you use a nonoverlapping range of private IP addresses for the cluster and service networks in each cluster.

Table 8.11. Network parameters

Parameter	Description	Values
networking	The configuration for the cluster network.	Object  **NOTE** You cannot modify parameters specified by the **networking** object after installation.

Parameter	Description	Values
networking.networkType	The cluster network provider Container Network Interface (CNI) cluster network provider to install.	Either **OpenShiftSDN** or **OVNKubernetes**. **OpenShiftSDN** is a CNI provider for all-Linux networks. **OVNKubernetes** is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is **OpenShiftSDN**.
networking.clusterNetwork	The IP address blocks for pods. The default value is **10.128.0.0/14** with a host prefix of **/23**. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: `networking:` `  clusterNetwork:` `  - cidr: 10.128.0.0/14` `    hostPrefix: 23`
networking.clusterNetwork.cidr	Required if you use **networking.clusterNetwork**. An IP address block. An IPv4 network.	An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between **0** and **32**.
networking.clusterNetwork.hostPrefix	The subnet prefix length to assign to each individual node. For example, if **hostPrefix** is set to **23** then each node is assigned a **/23** subnet out of the given **cidr**. A **hostPrefix** value of **23** provides 510 (2^(32 - 23) - 2) pod IP addresses.	A subnet prefix. The default value is **23**.
networking.serviceNetwork	The IP address block for services. The default value is **172.30.0.0/16**. The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.	An array with an IP address block in CIDR format. For example: `networking:` `  serviceNetwork:` `   - 172.30.0.0/16`
networking.machineNetwork	The IP address blocks for machines. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: `networking:` `  machineNetwork:` `  - cidr: 10.0.0.0/16`

Parameter	Description	Values
networking.machineNetwork.cidr	Required if you use **networking.machineNetwork**. An IP address block. The default value is **10.0.0.0/16** for all platforms other than libvirt. For libvirt, the default value is **192.168.126.0/24**.	An IP network block in CIDR notation. For example, **10.0.0.0/16**.  **NOTE** Set the **networking.machineNetwork** to match the CIDR that the preferred NIC resides in.

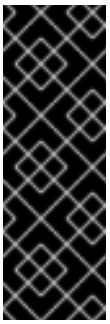
8.6.5.1.3. Optional configuration parameters

Optional installation configuration parameters are described in the following table:

Table 8.12. Optional parameters

Parameter	Description	Values
additionalTrustBundle	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String
capabilities	Controls the installation of optional core cluster components. You can reduce the footprint of your OpenShift Container Platform cluster by disabling optional components.	String array
capabilities.baselineCapabilitySet	Selects an initial set of optional capabilities to enable. Valid values are **None**, **v4.11** and **vCurrent**. **v4.11** enables the **baremetal** Operator, the **marketplace** Operator, and the **openshift-samples** content. **vCurrent** installs the recommended set of capabilities for the current version of OpenShift Container Platform. The default value is **vCurrent**.	String

Parameter	Description	Values
capabilities.additionalEnabledCapabilities	Extends the set of optional capabilities beyond what you specify in **baselineCapabilitySet**. Valid values are **baremetal**, **marketplace** and **openshift-samples**. You may specify multiple capabilities in this parameter.	String array
cgroupsV2	Enables Linux control groups version 2 (cgroups v2) on specific nodes in your cluster. The OpenShift Container Platform process for enabling cgroups v2 disables all cgroup version 1 controllers and hierarchies. The OpenShift Container Platform cgroups version 2 feature is in Developer Preview and is not supported by Red Hat at this time.	**true**
compute	The configuration for the machines that comprise the compute nodes.	Array of **MachinePool** objects.
compute.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** (the default).	String
compute.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  IMPORTANT If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
compute.name	Required if you use **compute**. The name of the machine pool.	**worker**

Parameter	Description	Values
compute.platform	Required if you use **compute**. Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the **controlPlane.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
compute.replicas	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to **2**. The default value is **3**.
controlPlane	The configuration for the machines that comprise the control plane.	Array of **MachinePool** objects.
controlPlane.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** (the default).	String
controlPlane.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  IMPORTANT If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
controlPlane.name	Required if you use **controlPlane**. The name of the machine pool.	**master**

Parameter	Description	Values
controlPlane.platform	Required if you use **controlPlane**. Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the **compute.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
controlPlane.replicas	The number of control plane machines to provision.	The only supported value is **3**, which is the default value.
credentialsMode	The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported. If you are installing on GCP into a shared virtual private cloud (VPC), **credentialsMode** must be set to **Passthrough**.  NOTE Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the *Cloud Credential Operator* entry in the *Cluster Operators reference* content.  NOTE If your AWS account has service control policies (SCP) enabled, you must configure the **credentialsMode** parameter to **Mint**, **Passthrough** or **Manual**.	**Mint**, **Passthrough**, **Manual** or an empty string (**""**).
fips	Enable or disable FIPS mode. The default is **false** (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default	**false** or **true**

Parameter	Description	Values
	Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.  **IMPORTANT** To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.  **NOTE** If you are using Azure File storage, you cannot enable FIPS mode.	

Parameter	Description	Values
imageContentSources	Sources and repositories for the release-image content.	Array of objects. Includes a **source** and, optionally, **mirrors**, as described in the following rows of this table.
imageContentSources.source	Required if you use **imageContentSources**. Specify the repository that users refer to, for example, in image pull specifications.	String
imageContentSources.mirrors	Specify one or more repositories that may also contain the same images.	Array of strings
publish	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	**Internal** or **External**. To deploy a private cluster, which cannot be accessed from the internet, set **publish** to **Internal**. The default value is **External**.
sshKey	The SSH key to authenticate access to your cluster machines.  **NOTE** For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.	For example, **sshKey: ssh-ed25519 AAAA..**.

8.6.5.1.4. Additional Google Cloud Platform (GCP) configuration parameters

Additional GCP configuration parameters are described in the following table:

Table 8.13. Additional GCP parameters

Parameter	Description	Values
platform.gcp.network	The name of the existing VPC that you want to deploy your cluster to.	String.

Parameter	Description	Values
platform.gcp.projectID	The name of the GCP project where the installation program installs the cluster.	String.
platform.gcp.region	The name of the GCP region that hosts your cluster.	Any valid region name, such as **us-central1**.
platform.gcp.controlPlaneSubnet	The name of the existing subnet in your VPC that you want to deploy your control plane machines to.	The subnet name.
platform.gcp.computeSubnet	The name of the existing subnet in your VPC that you want to deploy your compute machines to.	The subnet name.
platform.gcp.licenses	A list of license URLs that must be applied to the compute images.  **IMPORTANT** The **licenses** parameter is a deprecated field and nested virtualization is enabled by default. It is not recommended to use this field.	Any license available with the license API, such as the license to enable nested virtualization. You cannot use this parameter with a mechanism that generates pre-built images. Using a license URL forces the installer to copy the source image before use.
platform.gcp.defaultMachinePlatform.osDisk.diskSizeGB	The size of the disk in gigabytes (GB).	Any size between 16 GB and 65536 GB.

Parameter	Description	Values
platform.gcp.defaultMachinePlatform.osDisk.diskType	The type of disk.	Either the default **pd-ssd** or the **pd-standard** disk type. The control plane nodes must be the **pd-ssd** disk type. The worker nodes can be either type.
platform.gcp.defaultMachinePlatform.osImage.project	Optional. By default, the installation program downloads and installs the RHCOS image that is used to boot control plane and compute machines. You can override the default behavior by specifying the location of a custom RHCOS image for the installation program to use for both types of machines.	String. The name of GCP project where the image is located.
platform.gcp.defaultMachinePlatform.osImage.name	The name of the custom RHCOS image for the installation program to use to boot control plane and compute machines. If you use **platform.gcp.defaultMachinePlatform.osImage.project**, this field is required.	String. The name of the RHCOS image.
platform.gcp.defaultMachinePlatform.type	The GCP machine type.	The GCP machine type.
platform.gcp.defaultMachinePlatform.zones	The availability zones where the installation program creates machines for the specified MachinePool.	A list of valid GCP availability zones, such as **us-central1-a**, in a YAML sequence.

Parameter	Description	Values
controlPlane.platform.gcp.osDisk.encryptionKey.kmsKey.name	The name of the customer managed encryption key to be used for control plane machine disk encryption.	The encryption key name.
controlPlane.platform.gcp.osDisk.encryptionKey.kmsKey.keyRing	For control plane machines, the name of the KMS key ring to which the KMS key belongs.	The KMS key ring name.
controlPlane.platform.gcp.osDisk.encryptionKey.kmsKey.location	For control plane machines, the GCP location in which the key ring exists. For more information on KMS locations, see Google's documentation on Cloud KMS locations.	The GCP location for the key ring.
controlPlane.platform.gcp.osDisk.encryptionKey.kmsKey.projectID	For control plane machines, the ID of the project in which the KMS key ring exists. This value defaults to the VM project ID if not set.	The GCP project ID.

Parameter	Description	Values
controlPlane.platform.gcp.osImage.project	Optional. By default, the installation program downloads and installs the Red Hat Enterprise Linux CoreOS (RHCOS) image that is used to boot control plane machines. You can override the default behavior by specifying the location of a custom RHCOS image for the installation program to use for control plane machines only.	String. The name of GCP project where the image is located.
controlPlane.platform.gcp.osImage.name	The name of the custom RHCOS image for the installation program to use to boot control plane machines. If you use **controlPlane.platform.gcp.osImage.project**, this field is required.	String. The name of the RHCOS image.
compute.platform.gcp.osDisk.encryptionKey.kmsKey.name	The name of the customer managed encryption key to be used for compute machine disk encryption.	The encryption key name.
compute.platform.gcp.osDisk.encryptionKey.kmsKey.keyRing	For compute machines, the name of the KMS key ring to which the KMS key belongs.	The KMS key ring name.

Parameter	Description	Values
compute.platform.gcp.osDisk.encryptionKey.kmsKey.location	For compute machines, the GCP location in which the key ring exists. For more information on KMS locations, see Google's documentation on Cloud KMS locations.	The GCP location for the key ring.
compute.platform.gcp.osDisk.encryptionKey.kmsKey.projectID	For compute machines, the ID of the project in which the KMS key ring exists. This value defaults to the VM project ID if not set.	The GCP project ID.
compute.platform.gcp.osImage.project	Optional. By default, the installation program downloads and installs the RHCOS image that is used to boot compute machines. You can override the default behavior by specifying the location of a custom RHCOS image for the installation program to use for compute machines only.	String. The name of GCP project where the image is located.
compute.platform.gcp.osImage.name	The name of the custom RHCOS image for the installation program to use to boot compute machines. If you use **compute.platform.gcp.osImage.project**, this field is required.	String. The name of the RHCOS image.

8.6.5.2. Minimum resource requirements for cluster installation

Each cluster machine must meet the following minimum requirements:

Table 8.14. Minimum resource requirements

Machine	Operating System	vCPU [1]	Virtual RAM	Storage	IOPS [2]
Bootstrap	RHCOS	4	16 GB	100 GB	300
Control plane	RHCOS	4	16 GB	100 GB	300
Compute	RHCOS, RHEL 8.6 and later [3]	2	8 GB	100 GB	300

1. One vCPU is equivalent to one physical core when simultaneous multithreading (SMT), or hyperthreading, is not enabled. When enabled, use the following formula to calculate the corresponding ratio: (threads per core × cores) × sockets = vCPUs.

2. OpenShift Container Platform and Kubernetes are sensitive to disk performance, and faster storage is recommended, particularly for etcd on the control plane nodes which require a 10 ms p99 fsync duration. Note that on many cloud platforms, storage size and IOPS scale together, so you might need to over-allocate storage volume to obtain sufficient performance.

3. As with all user-provisioned installations, if you choose to use RHEL compute machines in your cluster, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks. Use of RHEL 7 compute machines is deprecated and has been removed in OpenShift Container Platform 4.10 and later.

If an instance type for your platform meets the minimum requirements for cluster machines, it is supported to use in OpenShift Container Platform.

Additional resources

- Optimizing storage

8.6.5.3. Tested instance types for GCP

The following Google Cloud Platform instance types have been tested with OpenShift Container Platform.

> **Example 8.22. Machine series**
>
> - **C2**
> - **C2D**
> - **C3**
> - **E2**
> - **M1**
> - **N1**
> - **N2**

- **N2D**
- **Tau T2D**

8.6.5.4. Using custom machine types

Using a custom machine type to install a OpenShift Container Platform cluster is supported.

Consider the following when using a custom machine type:

- Similar to predefined instance types, custom machine types must meet the minimum resource requirements for control plane and compute machines. For more information, see "Minimum resource requirements for cluster installation".
- The name of the custom machine type must adhere to the following syntax: **custom-<number_of_cpus>-<amount_of_memory_in_mb>**

  For example, **custom-6-20480**.

As part of the installation process, you specify the custom machine type in the **install-config.yaml** file.

Sample install-config.yaml file with a custom machine type

```
compute:
- architecture: amd64
  hyperthreading: Enabled
  name: worker
  platform:
    gcp:
      type: custom-6-20480
  replicas: 2
controlPlane:
  architecture: amd64
  hyperthreading: Enabled
  name: master
  platform:
    gcp:
      type: custom-6-20480
  replicas: 3
```

8.6.5.5. Sample customized install-config.yaml file for GCP

You can customize the **install-config.yaml** file to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.

IMPORTANT

This sample YAML file is provided for reference only. You must obtain your **install-config.yaml** file by using the installation program and modify it.

```
apiVersion: v1
baseDomain: example.com (1)
controlPlane: (2) (3)
```

```
  hyperthreading: Enabled (4)
  name: master
  platform:
    gcp:
      type: n2-standard-4
      zones:
      - us-central1-a
      - us-central1-c
      osDisk:
        diskType: pd-ssd
        diskSizeGB: 1024
        encryptionKey: (5)
          kmsKey:
            name: worker-key
            keyRing: test-machine-keys
            location: global
            projectID: project-id
        osImage: (6)
          project: example-project-name
          name: example-image-name
  replicas: 3
compute: (7) (8)
- hyperthreading: Enabled (9)
  name: worker
  platform:
    gcp:
      type: n2-standard-4
      zones:
      - us-central1-a
      - us-central1-c
      osDisk:
        diskType: pd-standard
        diskSizeGB: 128
        encryptionKey: (10)
          kmsKey:
            name: worker-key
            keyRing: test-machine-keys
            location: global
            projectID: project-id
        osImage: (11)
          project: example-project-name
          name: example-image-name
  replicas: 3
metadata:
  name: test-cluster (12)
networking: (13)
  clusterNetwork:
  - cidr: 10.128.0.0/14
    hostPrefix: 23
  machineNetwork:
  - cidr: 10.0.0.0/16
  networkType: OpenShiftSDN
  serviceNetwork:
  - 172.30.0.0/16
platform:
```

```
  gcp:
    projectID: openshift-production 14
    region: us-central1 15
    defaultMachinePlatform:
      osImage: 16
        project: example-project-name
        name: example-image-name
pullSecret: '{"auths": ...}' 17
fips: false 18
sshKey: ssh-ed25519 AAAA... 19
```

1 12 14 15 17 Required. The installation program prompts you for this value.

2 7 13 If you do not provide these parameters and values, the installation program provides the default value.

3 8 The **controlPlane** section is a single mapping, but the **compute** section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, **-**, and the first line of the **controlPlane** section must not. Only one control plane pool is used.

4 9 Whether to enable or disable simultaneous multithreading, or **hyperthreading**. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores. You can disable it by setting the parameter value to **Disabled**. If you disable simultaneous multithreading in some cluster machines, you must disable it in all cluster machines.

IMPORTANT

If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance. Use larger machine types, such as **n1-standard-8**, for your machines if you disable simultaneous multithreading.

5 10 Optional: The custom encryption key section to encrypt both virtual machines and persistent volumes. Your default compute service account must have the permissions granted to use your KMS key and have the correct IAM role assigned. The default service account name follows the **service-<project_number>@compute-system.iam.gserviceaccount.com** pattern. For more information on granting the correct permissions for your service account, see "Machine management" → "Creating machine sets" → "Creating a machine set on GCP".

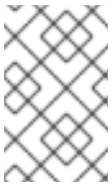
6 11 16 Optional: A custom Red Hat Enterprise Linux CoreOS (RHCOS) image for the installation program to use to boot control plane and compute machines. The **project** and **name** parameters under **platform.gcp.defaultMachinePlatform.osImage** apply to both control plane and compute machines. If the **project** and **name** parameters under **controlPlane.platform.gcp.osImage** or **compute.platform.gcp.osImage** are set, they override the **platform.gcp.defaultMachinePlatform.osImage** parameters.

18 Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.

IMPORTANT

To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.

19 You can optionally provide the **sshKey** value that you use to access the machines in your cluster.



NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

8.6.6. Additional resources

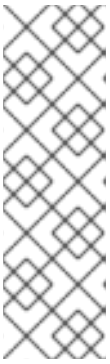
- Enabling customer-managed encryption keys for a machine set

8.6.6.1. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.



NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

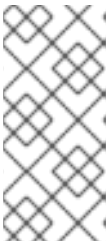
```
apiVersion: v1
baseDomain: my.domain.com
```

```
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
```

1. A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
2. A proxy URL to use for creating HTTPS connections outside the cluster.
3. A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use * to bypass the proxy for all destinations.
4. If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace that contains one or more additional CA certificates that are required for proxying HTTPS connections. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges these contents with the Red Hat Enterprise Linux CoreOS (RHCOS) trust bundle, and this config map is referenced in the **trustedCA** field of the **Proxy** object. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.

NOTE

The installation program does not support the proxy **readinessEndpoints** field.



NOTE

If the installer times out, restart and then complete the deployment by using the **wait-for** command of the installer. For example:

```
$ ./openshift-install wait-for install-complete --log-level debug
```

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.

NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

8.6.7. Network configuration phases

There are two phases prior to OpenShift Container Platform installation where you can customize the network configuration.

Phase 1

You can customize the following network-related fields in the **install-config.yaml** file before you create the manifest files:

- **networking.networkType**
- **networking.clusterNetwork**
- **networking.serviceNetwork**
- **networking.machineNetwork**
  For more information on these fields, refer to *Installation configuration parameters*.

NOTE

Set the **networking.machineNetwork** to match the CIDR that the preferred NIC resides in.

IMPORTANT

The CIDR range **172.17.0.0/16** is reserved by libVirt. You cannot use this range or any range that overlaps with this range for any networks in your cluster.

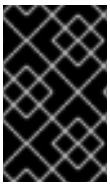
Phase 2

After creating the manifest files by running **openshift-install create manifests**, you can define a customized Cluster Network Operator manifest with only the fields you want to modify. You can use the manifest to specify advanced network configuration.

You cannot override the values specified in phase 1 in the **install-config.yaml** file during phase 2. However, you can further customize the cluster network provider during phase 2.

8.6.8. Specifying advanced network configuration

You can use advanced network configuration for your cluster network provider to integrate your cluster into your existing network environment. You can specify advanced network configuration only before you install the cluster.



IMPORTANT

Customizing your network configuration by modifying the OpenShift Container Platform manifest files created by the installation program is not supported. Applying a manifest file that you create, as in the following procedure, is supported.

Prerequisites

- You have created the **install-config.yaml** file and completed any modifications to it.

Procedure

1. Change to the directory that contains the installation program and create the manifests:

```
$ ./openshift-install create manifests --dir <installation_directory> 1
```

1 **<installation_directory>** specifies the name of the directory that contains the **install-config.yaml** file for your cluster.

2. Create a stub manifest file for the advanced network configuration that is named **cluster-network-03-config.yml** in the **<installation_directory>/manifests/** directory:

```
apiVersion: operator.openshift.io/v1
kind: Network
metadata:
  name: cluster
spec:
```

3. Specify the advanced network configuration for your cluster in the **cluster-network-03-config.yml** file, such as in the following examples:

Specify a different VXLAN port for the OpenShift SDN network provider

```
apiVersion: operator.openshift.io/v1
kind: Network
metadata:
  name: cluster
spec:
  defaultNetwork:
    openshiftSDNConfig:
      vxlanPort: 4800
```

Enable IPsec for the OVN-Kubernetes network provider

```
apiVersion: operator.openshift.io/v1
kind: Network
metadata:
  name: cluster
spec:
  defaultNetwork:
    ovnKubernetesConfig:
      ipsecConfig: {}
```

4. Optional: Back up the **manifests/cluster-network-03-config.yml** file. The installation program consumes the **manifests/** directory when you create the Ignition config files.

8.6.9. Cluster Network Operator configuration

The configuration for the cluster network is specified as part of the Cluster Network Operator (CNO) configuration and stored in a custom resource (CR) object that is named **cluster**. The CR specifies the fields for the **Network** API in the **operator.openshift.io** API group.

The CNO configuration inherits the following fields during cluster installation from the **Network** API in the **Network.config.openshift.io** API group and these fields cannot be changed:

clusterNetwork

IP address pools from which pod IP addresses are allocated.

serviceNetwork

IP address pool for services.

defaultNetwork.type

Cluster network provider, such as OpenShift SDN or OVN-Kubernetes.

You can specify the cluster network provider configuration for your cluster by setting the fields for the **defaultNetwork** object in the CNO object named **cluster**.

8.6.9.1. Cluster Network Operator configuration object

The fields for the Cluster Network Operator (CNO) are described in the following table:

Table 8.15. Cluster Network Operator configuration object

Field	Type	Description
metadata.name	**string**	The name of the CNO object. This name is always **cluster**.
spec.clusterNetwork	**array**	A list specifying the blocks of IP addresses from which pod IP addresses are allocated and the subnet prefix length assigned to each individual node in the cluster. For example: `spec:` `  clusterNetwork:` `  - cidr: 10.128.0.0/19` `  hostPrefix: 23` `  - cidr: 10.128.32.0/19` `  hostPrefix: 23` You can customize this field only in the **install-config.yaml** file before you create the manifests. The value is read-only in the manifest file.
spec.serviceNetwork	**array**	A block of IP addresses for services. The OpenShift SDN and OVN-Kubernetes Container Network Interface (CNI) network providers support only a single IP address block for the service network. For example: `spec:` `  serviceNetwork:` `  - 172.30.0.0/14` You can customize this field only in the **install-config.yaml** file before you create the manifests. The value is read-only in the manifest file.
spec.defaultNetwork	**object**	Configures the Container Network Interface (CNI) cluster network provider for the cluster network.

Field	Type	Description
spec.kubeProxyConfig	**object**	The fields for this object specify the kube-proxy configuration. If you are using the OVN-Kubernetes cluster network provider, the kube-proxy configuration has no effect.

defaultNetwork object configuration
The values for the **defaultNetwork** object are defined in the following table:

Table 8.16. **defaultNetwork** object

Field	Type	Description
type	**string**	Either **OpenShiftSDN** or **OVNKubernetes**. The cluster network provider is selected during installation. This value cannot be changed after cluster installation.  **NOTE** OpenShift Container Platform uses the OpenShift SDN Container Network Interface (CNI) cluster network provider by default.
openshiftSDNConfig	**object**	This object is only valid for the OpenShift SDN cluster network provider.
ovnKubernetesConfig	**object**	This object is only valid for the OVN-Kubernetes cluster network provider.

Configuration for the OpenShift SDN CNI cluster network provider
The following table describes the configuration fields for the OpenShift SDN Container Network Interface (CNI) cluster network provider.

Table 8.17. **openshiftSDNConfig** object

Field	Type	Description
mode	**string**	Configures the network isolation mode for OpenShift SDN. The default value is **NetworkPolicy**. The values **Multitenant** and **Subnet** are available for backwards compatibility with OpenShift Container Platform 3.x but are not recommended. This value cannot be changed after cluster installation.

Field	Type	Description
mtu	**integer**	The maximum transmission unit (MTU) for the VXLAN overlay network. This is detected automatically based on the MTU of the primary network interface. You do not normally need to override the detected MTU. If the auto-detected value is not what you expect it to be, confirm that the MTU on the primary network interface on your nodes is correct. You cannot use this option to change the MTU value of the primary network interface on the nodes. If your cluster requires different MTU values for different nodes, you must set this value to **50** less than the lowest MTU value in your cluster. For example, if some nodes in your cluster have an MTU of **9001**, and some have an MTU of**1500**, you must set this value to **1450**. This value cannot be changed after cluster installation.
vxlanPort	**integer**	The port to use for all VXLAN packets. The default value is **4789**. This value cannot be changed after cluster installation. If you are running in a virtualized environment with existing nodes that are part of another VXLAN network, then you might be required to change this. For example, when running an OpenShift SDN overlay on top of VMware NSX-T, you must select an alternate port for the VXLAN, because both SDNs use the same default VXLAN port number. On Amazon Web Services (AWS), you can select an alternate port for the VXLAN between port **9000** and port **9999**.

Example OpenShift SDN configuration

```
defaultNetwork:
  type: OpenShiftSDN
  openshiftSDNConfig:
    mode: NetworkPolicy
    mtu: 1450
    vxlanPort: 4789
```

Configuration for the OVN-Kubernetes CNI cluster network provider

The following table describes the configuration fields for the OVN-Kubernetes CNI cluster network provider.

Table 8.18. **ovnKubernetesConfig** object

Field	Type	Description
mtu	**integer**	The maximum transmission unit (MTU) for the Geneve (Generic Network Virtualization Encapsulation) overlay network. This is detected automatically based on the MTU of the primary network interface. You do not normally need to override the detected MTU. If the auto-detected value is not what you expect it to be, confirm that the MTU on the primary network interface on your nodes is correct. You cannot use this option to change the MTU value of the primary network interface on the nodes. If your cluster requires different MTU values for different nodes, you must set this value to **100** less than the lowest MTU value in your cluster. For example, if some nodes in your cluster have an MTU of **9001**, and some have an MTU of**1500**, you must set this value to **1400**.
genevePort	**integer**	The port to use for all Geneve packets. The default value is **6081**. This value cannot be changed after cluster installation.
ipsecConfig	**object**	Specify an empty object to enable IPsec encryption.
policyAuditConfig	**object**	Specify a configuration object for customizing network policy audit logging. If unset, the defaults audit log settings are used.
gatewayConfig	**object**	Optional: Specify a configuration object for customizing how egress traffic is sent to the node gateway.  **NOTE** While migrating egress traffic, you can expect some disruption to workloads and service traffic until the Cluster Network Operator (CNO) successfully rolls out the changes.

Table 8.19. **policyAuditConfig** object

Field	Type	Description
rateLimit	integer	The maximum number of messages to generate every second per node. The default value is **20** messages per second.
maxFileSize	integer	The maximum size for the audit log in bytes. The default value is **50000000** or 50 MB.

Field	Type	Description
destination	string	One of the following additional audit log targets: **libc** The libc **syslog()** function of the journald process on the host. **udp:<host>:<port>** A syslog server. Replace **<host>:<port>** with the host and port of the syslog server. **unix:<file>** A Unix Domain Socket file specified by **<file>**. **null** Do not send the audit logs to any additional target.
syslogFacility	string	The syslog facility, such as **kern**, as defined by RFC5424. The default value is **local0**.

Table 8.20. **gatewayConfig** object

Field	Type	Description
routingViaHost	**boolean**	Set this field to **true** to send egress traffic from pods to the host networking stack. For highly-specialized installations and applications that rely on manually configured routes in the kernel routing table, you might want to route egress traffic to the host networking stack. By default, egress traffic is processed in OVN to exit the cluster and is not affected by specialized routes in the kernel routing table. The default value is **false**. This field has an interaction with the Open vSwitch hardware offloading feature. If you set this field to **true**, you do not receive the performance benefits of the offloading because egress traffic is processed by the host networking stack.

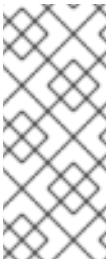
Example OVN-Kubernetes configuration with IPSec enabled

```
defaultNetwork:
  type: OVNKubernetes
  ovnKubernetesConfig:
    mtu: 1400
    genevePort: 6081
    ipsecConfig: {}
```

kubeProxyConfig object configuration

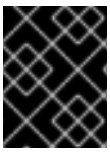
The values for the **kubeProxyConfig** object are defined in the following table:

Table 8.21. **kubeProxyConfig** object

Field	Type	Description
iptablesSyncPeriod	**string**	The refresh period for **iptables** rules. The default value is **30s**. Valid suffixes include **s**, **m**, and **h** and are described in the Go **time** package documentation.  **NOTE** Because of performance improvements introduced in OpenShift Container Platform 4.3 and greater, adjusting the **iptablesSyncPeriod** parameter is no longer necessary.
proxyArguments.iptables-min-sync-period	**array**	The minimum duration before refreshing **iptables** rules. This field ensures that the refresh does not happen too frequently. Valid suffixes include **s**, **m**, and **h** and are described in the Go **time** package. The default value is: `kubeProxyConfig:` `  proxyArguments:` `  iptables-min-sync-period:` `  - 0s`

8.6.10. Deploying the cluster

You can install OpenShift Container Platform on a compatible cloud platform.



IMPORTANT

You can run the **create cluster** command of the installation program only once, during initial installation.

Prerequisites

- Configure an account with the cloud platform that hosts your cluster.
- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.

Procedure

1. Remove any existing GCP credentials that do not use the service account key for the GCP account that you configured for your cluster and that are stored in the following locations:
   - The **GOOGLE_CREDENTIALS**, **GOOGLE_CLOUD_KEYFILE_JSON**, or **GCLOUD_KEYFILE_JSON** environment variables
   - The ~/**.gcp/osServiceAccount.json** file

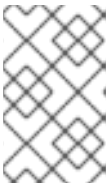
- The **gcloud cli** default credentials

2. Change to the directory that contains the installation program and initialize the cluster deployment:

```
$ ./openshift-install create cluster --dir <installation_directory> \ 1
    --log-level=info 2
```

1 For **<installation_directory>**, specify the location of your customized **./install-config.yaml** file.

2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.



NOTE

If the cloud provider account that you configured on your host does not have sufficient permissions to deploy the cluster, the installation process stops, and the missing permissions are displayed.

3. Optional: You can reduce the number of permissions for the service account that you used to install the cluster.

- If you assigned the **Owner** role to your service account, you can remove that role and replace it with the **Viewer** role.
- If you included the **Service Account Key Admin** role, you can remove it.

Verification

When the cluster deployment completes successfully:

- The terminal displays directions for accessing your cluster, including a link to the web console and credentials for the **kubeadmin** user.
- Credential information also outputs to **<installation_directory>/.openshift_install.log**.

IMPORTANT

Do not delete the installation program or the files that the installation program creates. Both are required to delete the cluster.

Example output

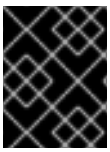
```
...
INFO Install complete!
INFO To access the cluster as the system:admin user when using 'oc', run 'export
KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
INFO Access the OpenShift web-console here: https://console-openshift-
console.apps.mycluster.example.com
INFO Login to the console with user: "kubeadmin", and password: "password"
INFO Time elapsed: 36m22s
```

IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

8.6.11. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.



IMPORTANT

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.11. Download and install the new version of **oc**.

Installing the OpenShift CLI on Linux

You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the architecture in the **Product Variant** drop-down menu.
3. Select the appropriate version in the **Version** drop-down menu.
4. Click **Download Now** next to the **OpenShift v4.11 Linux Client** entry and save the file.
5. Unpack the archive:

```
$ tar xvf <file>
```

6. Place the **oc** binary in a directory that is on your **PATH**.
   To check your **PATH**, execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

–

Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.
   To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
C:\> oc <command>
```

Installing the OpenShift CLI on macOS

You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 macOS Client** entry and save the file.

NOTE

For macOS arm64, choose the **OpenShift v4.11 macOS arm64 Client** entry.

4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your PATH.
   To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

8.6.12. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

Example output

```
system:admin
```

Additional resources

- See Accessing the web console for more details about accessing and understanding the OpenShift Container Platform web console.

8.6.13. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.11, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to OpenShift Cluster Manager Hybrid Cloud Console.

After you confirm that your OpenShift Cluster Manager Hybrid Cloud Console inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, use subscription watch to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

Additional resources

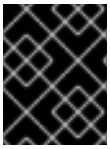
- See About remote health monitoring for more information about the Telemetry service

8.6.14. Next steps

- Customize your cluster.
- If necessary, you can opt out of remote health reporting .

8.7. INSTALLING A CLUSTER ON GCP IN A RESTRICTED NETWORK

In OpenShift Container Platform 4.11, you can install a cluster on Google Cloud Platform (GCP) in a restricted network by creating an internal mirror of the installation release content on an existing Google Virtual Private Cloud (VPC).

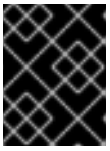


IMPORTANT

You can install an OpenShift Container Platform cluster by using mirrored installation release content, but your cluster will require internet access to use the GCP APIs.

8.7.1. Prerequisites

- You reviewed details about the OpenShift Container Platform installation and update processes.
- You read the documentation on selecting a cluster installation method and preparing it for users.
- You configured a GCP project to host the cluster.
- You mirrored the images for a disconnected installation to your registry and obtained the **imageContentSources** data for your version of OpenShift Container Platform.

  IMPORTANT

  Because the installation media is on the mirror host, you can use that computer to complete all installation steps.

- You have an existing VPC in GCP. While installing a cluster in a restricted network that uses installer-provisioned infrastructure, you cannot use the installer-provisioned VPC. You must use a user-provisioned VPC that satisfies one of the following requirements:
  - Contains the mirror registry
  - Has firewall rules or a peering connection to access the mirror registry hosted elsewhere
- If you use a firewall, you configured it to allow the sites that your cluster requires access to. While you might need to grant access to more sites, you must grant access to ***.googleapis.com** and **accounts.google.com**.
- If the cloud identity and access management (IAM) APIs are not accessible in your environment, or if you do not want to store an administrator-level credential secret in the **kube-system** namespace, you can manually create and maintain IAM credentials.

8.7.2. About installations in restricted networks

In OpenShift Container Platform 4.11, you can perform an installation that does not require an active

connection to the internet to obtain software components. Restricted network installations can be completed using installer-provisioned infrastructure or user-provisioned infrastructure, depending on the cloud platform to which you are installing the cluster.

If you choose to perform a restricted network installation on a cloud platform, you still require access to its cloud APIs. Some cloud functions, like Amazon Web Service's Route 53 DNS and IAM services, require internet access. Depending on your network, you might require less internet access for an installation on bare metal hardware or on VMware vSphere.

To complete a restricted network installation, you must create a registry that mirrors the contents of the OpenShift image registry and contains the installation media. You can create this registry on a mirror host, which can access both the internet and your closed network, or by using other methods that meet your restrictions.

8.7.2.1. Additional limits

Clusters in restricted networks have the following additional limitations and restrictions:

- The **ClusterVersion** status includes an **Unable to retrieve available updates** error.
- By default, you cannot use the contents of the Developer Catalog because you cannot access the required image stream tags.

8.7.3. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.11, you require access to the internet to obtain the images that are necessary to install your cluster.

You must have internet access to:

- Access OpenShift Cluster Manager Hybrid Cloud Console to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access Quay.io to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.

IMPORTANT

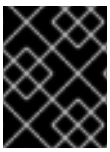
If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

8.7.4. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the **~/.ssh/authorized_keys** list for the **core** user on each node, which enables password-less authentication.

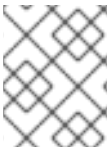
After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The **./openshift-install gather** command also requires the SSH public key to be in place on the cluster nodes.



IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.



NOTE

You must use a local key, not one that you configured with platform-specific approaches such as AWS key pairs.

Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N '' -f <path>/<file_name> 1
```

1 Specify the path and file name, such as ~/**.ssh/id_ed25519**, of the new SSH key. If you have an existing key pair, ensure your public key is in the your ~/**.ssh** directory.

NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS validated or Modules In Process cryptographic libraries on the **x86_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

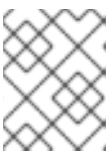
2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the ~/**.ssh/id_ed25519.pub** public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the **./openshift-install gather** command.



NOTE

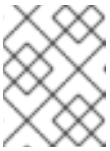
On some distributions, default SSH private key identities such as ~/**.ssh/id_rsa** and ~/**.ssh/id_dsa** are managed automatically.

a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

Example output

```
Agent pid 31874
```



NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

1 Specify the path and file name for your SSH private key, such as **~/.ssh/id_ed25519**

Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

5. Set the **GOOGLE_APPLICATION_CREDENTIALS** environment variable to the full path to your service account private key file.

```
$ export GOOGLE_APPLICATION_CREDENTIALS="<your_service_account_file>"
```

6. Verify that the credentials were applied.

```
$ gcloud auth list
```

Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

8.7.5. Creating the installation configuration file

You can customize the OpenShift Container Platform cluster you install on Google Cloud Platform (GCP).

Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster. For a restricted network installation, these files are on your mirror host.
- Have the **imageContentSources** values that were generated during mirror registry creation.
- Obtain the contents of the certificate for your mirror registry.

- Obtain service principal permissions at the subscription level.

Procedure

1. Create the **install-config.yaml** file.

   a. Change to the directory that contains the installation program and run the following command:

   ```
   $ ./openshift-install create install-config --dir <installation_directory>
   ```
   (1)

   (1) For **<installation_directory>**, specify the directory name to store the files that the installation program creates.

   When specifying the directory:

   - Verify that the directory has the **execute** permission. This permission is required to run Terraform binaries under the installation directory.
   - Use an empty directory. Some installation assets, such as bootstrap X.509 certificates, have short expiration intervals, therefore you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

   b. At the prompts, provide the configuration details for your cloud:

      i. Optional: Select an SSH key to use to access your cluster machines.

      NOTE

      For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

      ii. Select **gcp** as the platform to target.

      iii. If you have not configured the service account key for your GCP account on your computer, you must obtain it from GCP and paste the contents of the file or enter the absolute path to the file.

      iv. Select the project ID to provision the cluster in. The default value is specified by the service account that you configured.

      v. Select the region to deploy the cluster to.

      vi. Select the base domain to deploy the cluster to. The base domain corresponds to the public DNS zone that you created for your cluster.

      vii. Enter a descriptive name for your cluster.

      viii. Paste the pull secret from the Red Hat OpenShift Cluster Manager .

2. Edit the **install-config.yaml** file to give the additional information that is required for an installation in a restricted network.

   a. Update the **pullSecret** value to contain the authentication information for your registry:

   ```
   pullSecret: '{"auths":{"<mirror_host_name>:5000": {"auth": "<credentials>","email":
   "you@example.com"}}}'
   ```

   For **<mirror_host_name>**, specify the registry domain name that you specified in the certificate for your mirror registry, and for **<credentials>**, specify the base64-encoded user name and password for your mirror registry.

   b. Add the **additionalTrustBundle** parameter and value.

   ```
   additionalTrustBundle: |
     -----BEGIN CERTIFICATE-----

   ZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZ
     -----END CERTIFICATE-----
   ```

   The value must be the contents of the certificate file that you used for your mirror registry. The certificate file can be an existing, trusted certificate authority, or the self-signed certificate that you generated for the mirror registry.

   c. Define the network and subnets for the VPC to install the cluster in under the parent **platform.gcp** field:

   ```
   network: <existing_vpc>
   controlPlaneSubnet: <control_plane_subnet>
   computeSubnet: <compute_subnet>
   ```

   For **platform.gcp.network**, specify the name for the existing Google VPC. For **platform.gcp.controlPlaneSubnet** and **platform.gcp.computeSubnet**, specify the existing subnets to deploy the control plane machines and compute machines, respectively.

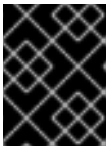
   d. Add the image content resources, which resemble the following YAML excerpt:

   ```
   imageContentSources:
   - mirrors:
     - <mirror_host_name>:5000/<repo_name>/release
     source: quay.io/openshift-release-dev/ocp-release
   - mirrors:
     - <mirror_host_name>:5000/<repo_name>/release
     source: registry.redhat.io/ocp/release
   ```

   For these values, use the **imageContentSources** that you recorded during mirror registry creation.

3. Make any other modifications to the **install-config.yaml** file that you require. You can find more information about the available parameters in the **Installation configuration parameters** section.

4. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.



IMPORTANT

The **install-config.yaml** file is consumed during the installation process. If you want to reuse the file, you must back it up now.

8.7.5.1. Installation configuration parameters

Before you deploy an OpenShift Container Platform cluster, you provide parameter values to describe your account on the cloud platform that hosts your cluster and optionally customize your cluster's platform. When you create the **install-config.yaml** installation configuration file, you provide values for the required parameters through the command line. If you customize your cluster, you can modify the **install-config.yaml** file to provide more details about the platform.

NOTE

After installation, you cannot modify these parameters in the **install-config.yaml** file.

8.7.5.1.1. Required configuration parameters

Required installation configuration parameters are described in the following table:

Table 8.22. Required parameters

Parameter	Description	Values
apiVersion	The API version for the **install-config.yaml** content. The current version is **v1**. The installer may also support older API versions.	String
baseDomain	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the **baseDomain** and **metadata.name** parameter values that uses the **<metadata.name>.<baseDomain>** format.	A fully-qualified domain or subdomain name, such as **example.com**.
metadata	Kubernetes resource **ObjectMeta**, from which only the **name** parameter is consumed.	Object

Parameter	Description	Values
metadata.name	The name of the cluster. DNS records for the cluster are all subdomains of **{{.metadata.name}}.{{.baseDomain}}**.	String of lowercase letters, hyphens (**-**), and periods (**.**), such as **dev**.
platform	The configuration for the specific platform upon which to perform the installation: **alibabacloud**, **aws**, **baremetal**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**. For additional information about **platform.<platform>** parameters, consult the table for your specific platform that follows.	Object
pullSecret	Get a pull secret from the Red Hat OpenShift Cluster Manager to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	<pre>{ "auths":{ "cloud.openshift.com":{ "auth":"b3Blb=", "email":"you@example.com" }, "quay.io":{ "auth":"b3Blb=", "email":"you@example.com" } } }</pre>

8.7.5.1.2. Network configuration parameters

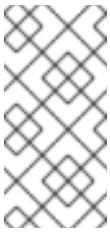
You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

Only IPv4 addresses are supported.

NOTE

Globalnet is not supported with Red Hat OpenShift Data Foundation disaster recovery solutions. For regional disaster recovery scenarios, ensure that you use a nonoverlapping range of private IP addresses for the cluster and service networks in each cluster.

Table 8.23. Network parameters

Parameter	Description	Values
networking	The configuration for the cluster network.	Object  **NOTE** You cannot modify parameters specified by the **networking** object after installation.
networking.networkType	The cluster network provider Container Network Interface (CNI) cluster network provider to install.	Either **OpenShiftSDN** or **OVNKubernetes**. **OpenShiftSDN** is a CNI provider for all-Linux networks. **OVNKubernetes** is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is **OpenShiftSDN**.
networking.clusterNetwork	The IP address blocks for pods. The default value is **10.128.0.0/14** with a host prefix of **/23**. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: `networking:` `  clusterNetwork:` `  - cidr: 10.128.0.0/14` `    hostPrefix: 23`
networking.clusterNetwork.cidr	Required if you use **networking.clusterNetwork**. An IP address block. An IPv4 network.	An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between **0** and **32**.
networking.clusterNetwork.hostPrefix	The subnet prefix length to assign to each individual node. For example, if **hostPrefix** is set to **23** then each node is assigned a **/23** subnet out of the given **cidr**. A **hostPrefix** value of **23** provides 510 (2^(32 - 23) - 2) pod IP addresses.	A subnet prefix. The default value is **23**.
networking.serviceNetwork	The IP address block for services. The default value is **172.30.0.0/16**. The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.	An array with an IP address block in CIDR format. For example: `networking:` `  serviceNetwork:` `  - 172.30.0.0/16`

Parameter	Description	Values
networking.machineNetwork	The IP address blocks for machines. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: `networking:` `  machineNetwork:` `  - cidr: 10.0.0.0/16`
networking.machineNetwork.cidr	Required if you use **networking.machineNetwork**. An IP address block. The default value is **10.0.0.0/16** for all platforms other than libvirt. For libvirt, the default value is **192.168.126.0/24**.	An IP network block in CIDR notation. For example, **10.0.0.0/16**. **NOTE** Set the **networking.machineNetwork** to match the CIDR that the preferred NIC resides in.

8.7.5.1.3. Optional configuration parameters

Optional installation configuration parameters are described in the following table:

Table 8.24. Optional parameters

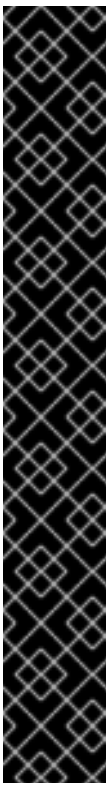
Parameter	Description	Values
additionalTrustBundle	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String
capabilities	Controls the installation of optional core cluster components. You can reduce the footprint of your OpenShift Container Platform cluster by disabling optional components.	String array

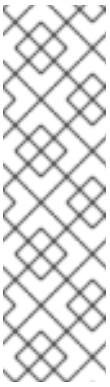
Parameter	Description	Values
capabilities.baselineCapabilitySet	Selects an initial set of optional capabilities to enable. Valid values are **None**, **v4.11** and **vCurrent**. **v4.11** enables the **baremetal** Operator, the **marketplace** Operator, and the **openshift-samples** content. **vCurrent** installs the recommended set of capabilities for the current version of OpenShift Container Platform. The default value is **vCurrent**.	String
capabilities.additionalEnabledCapabilities	Extends the set of optional capabilities beyond what you specify in **baselineCapabilitySet**. Valid values are **baremetal**, **marketplace** and **openshift-samples**. You may specify multiple capabilities in this parameter.	String array
cgroupsV2	Enables Linux control groups version 2 (cgroups v2) on specific nodes in your cluster. The OpenShift Container Platform process for enabling cgroups v2 disables all cgroup version 1 controllers and hierarchies. The OpenShift Container Platform cgroups version 2 feature is in Developer Preview and is not supported by Red Hat at this time.	**true**
compute	The configuration for the machines that comprise the compute nodes.	Array of **MachinePool** objects.
compute.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** (the default).	String

Parameter	Description	Values
compute.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  **IMPORTANT** If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
compute.name	Required if you use **compute**. The name of the machine pool.	**worker**
compute.platform	Required if you use **compute**. Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the **controlPlane.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
compute.replicas	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to **2**. The default value is **3**.
controlPlane	The configuration for the machines that comprise the control plane.	Array of **MachinePool** objects.
controlPlane.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** (the default).	String

Parameter	Description	Values
controlPlane.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  **IMPORTANT** If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
controlPlane.name	Required if you use **controlPlane**. The name of the machine pool.	**master**
controlPlane.platform	Required if you use **controlPlane**. Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the **compute.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
controlPlane.replicas	The number of control plane machines to provision.	The only supported value is **3**, which is the default value.

Parameter	Description	Values
credentialsMode	The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported. If you are installing on GCP into a shared virtual private cloud (VPC), **credentialsMode** must be set to **Passthrough**.  **NOTE** Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the *Cloud Credential Operator* entry in the *Cluster Operators reference* content.  **NOTE** If your AWS account has service control policies (SCP) enabled, you must configure the **credentialsMode** parameter to **Mint**, **Passthrough** or **Manual**.	**Mint**, **Passthrough**, **Manual** or an empty string (**""**).

Parameter	Description	Values
fips	Enable or disable FIPS mode. The default is **false** (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.  **IMPORTANT** To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.  **NOTE** If you are using Azure File storage, you cannot enable FIPS mode.	**false** or **true**

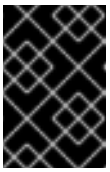
Parameter	Description	Values
imageContentSources	Sources and repositories for the release-image content.	Array of objects. Includes a **source** and, optionally, **mirrors**, as described in the following rows of this table.
imageContentSources.source	Required if you use **imageContentSources**. Specify the repository that users refer to, for example, in image pull specifications.	String
imageContentSources.mirrors	Specify one or more repositories that may also contain the same images.	Array of strings
publish	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	**Internal** or **External**. To deploy a private cluster, which cannot be accessed from the internet, set **publish** to **Internal**. The default value is **External**.
sshKey	The SSH key to authenticate access to your cluster machines.  NOTE For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.	For example, **sshKey: ssh-ed25519 AAAA..**.

8.7.5.1.4. Additional Google Cloud Platform (GCP) configuration parameters

Additional GCP configuration parameters are described in the following table:

Table 8.25. Additional GCP parameters

Parameter	Description	Values
platform.gcp.network	The name of the existing VPC that you want to deploy your cluster to.	String.

Parameter	Description	Values
platform.gcp.projectID	The name of the GCP project where the installation program installs the cluster.	String.
platform.gcp.region	The name of the GCP region that hosts your cluster.	Any valid region name, such as **us-central1**.
platform.gcp.controlPlaneSubnet	The name of the existing subnet in your VPC that you want to deploy your control plane machines to.	The subnet name.
platform.gcp.computeSubnet	The name of the existing subnet in your VPC that you want to deploy your compute machines to.	The subnet name.
platform.gcp.licenses	A list of license URLs that must be applied to the compute images.  **IMPORTANT** The **licenses** parameter is a deprecated field and nested virtualization is enabled by default. It is not recommended to use this field.	Any license available with the license API, such as the license to enable nested virtualization. You cannot use this parameter with a mechanism that generates pre-built images. Using a license URL forces the installer to copy the source image before use.
platform.gcp.defaultMachinePlatform.osDisk.diskSizeGB	The size of the disk in gigabytes (GB).	Any size between 16 GB and 65536 GB.

Parameter	Description	Values
platform.gcp.defaultMachinePlatform.osDisk.diskType	The type of disk.	Either the default **pd-ssd** or the **pd-standard** disk type. The control plane nodes must be the **pd-ssd** disk type. The worker nodes can be either type.
platform.gcp.defaultMachinePlatform.osImage.project	Optional. By default, the installation program downloads and installs the RHCOS image that is used to boot control plane and compute machines. You can override the default behavior by specifying the location of a custom RHCOS image for the installation program to use for both types of machines.	String. The name of GCP project where the image is located.
platform.gcp.defaultMachinePlatform.osImage.name	The name of the custom RHCOS image for the installation program to use to boot control plane and compute machines. If you use **platform.gcp.defaultMachinePlatform.osImage.project**, this field is required.	String. The name of the RHCOS image.
platform.gcp.defaultMachinePlatform.type	The GCP machine type.	The GCP machine type.
platform.gcp.defaultMachinePlatform.zones	The availability zones where the installation program creates machines for the specified MachinePool.	A list of valid GCP availability zones, such as **us-central1-a**, in a YAML sequence.

Parameter	Description	Values
controlPlane.platform.gcp.osDisk.encryptionKey.kmsKey.name	The name of the customer managed encryption key to be used for control plane machine disk encryption.	The encryption key name.
controlPlane.platform.gcp.osDisk.encryptionKey.kmsKey.keyRing	For control plane machines, the name of the KMS key ring to which the KMS key belongs.	The KMS key ring name.
controlPlane.platform.gcp.osDisk.encryptionKey.kmsKey.location	For control plane machines, the GCP location in which the key ring exists. For more information on KMS locations, see Google's documentation on Cloud KMS locations.	The GCP location for the key ring.
controlPlane.platform.gcp.osDisk.encryptionKey.kmsKey.projectID	For control plane machines, the ID of the project in which the KMS key ring exists. This value defaults to the VM project ID if not set.	The GCP project ID.

Parameter	Description	Values
controlPlane.platform.gcp.osImage.project	Optional. By default, the installation program downloads and installs the Red Hat Enterprise Linux CoreOS (RHCOS) image that is used to boot control plane machines. You can override the default behavior by specifying the location of a custom RHCOS image for the installation program to use for control plane machines only.	String. The name of GCP project where the image is located.
controlPlane.platform.gcp.osImage.name	The name of the custom RHCOS image for the installation program to use to boot control plane machines. If you use **controlPlane.platform.gcp.osImage.project**, this field is required.	String. The name of the RHCOS image.
compute.platform.gcp.osDisk.encryptionKey.kmsKey.name	The name of the customer managed encryption key to be used for compute machine disk encryption.	The encryption key name.
compute.platform.gcp.osDisk.encryptionKey.kmsKey.keyRing	For compute machines, the name of the KMS key ring to which the KMS key belongs.	The KMS key ring name.

Parameter	Description	Values
compute.platform.gcp.osDisk.encryptionKey.kmsKey.location	For compute machines, the GCP location in which the key ring exists. For more information on KMS locations, see Google's documentation on Cloud KMS locations.	The GCP location for the key ring.
compute.platform.gcp.osDisk.encryptionKey.kmsKey.projectID	For compute machines, the ID of the project in which the KMS key ring exists. This value defaults to the VM project ID if not set.	The GCP project ID.
compute.platform.gcp.osImage.project	Optional. By default, the installation program downloads and installs the RHCOS image that is used to boot compute machines. You can override the default behavior by specifying the location of a custom RHCOS image for the installation program to use for compute machines only.	String. The name of GCP project where the image is located.
compute.platform.gcp.osImage.name	The name of the custom RHCOS image for the installation program to use to boot compute machines. If you use **compute.platform.gcp.osImage.project**, this field is required.	String. The name of the RHCOS image.

8.7.5.2. Minimum resource requirements for cluster installation

Each cluster machine must meet the following minimum requirements:

Table 8.26. Minimum resource requirements

Machine	Operating System	vCPU [1]	Virtual RAM	Storage	IOPS [2]
Bootstrap	RHCOS	4	16 GB	100 GB	300
Control plane	RHCOS	4	16 GB	100 GB	300
Compute	RHCOS, RHEL 8.6 and later [3]	2	8 GB	100 GB	300

1. One vCPU is equivalent to one physical core when simultaneous multithreading (SMT), or hyperthreading, is not enabled. When enabled, use the following formula to calculate the corresponding ratio: (threads per core × cores) × sockets = vCPUs.
2. OpenShift Container Platform and Kubernetes are sensitive to disk performance, and faster storage is recommended, particularly for etcd on the control plane nodes which require a 10 ms p99 fsync duration. Note that on many cloud platforms, storage size and IOPS scale together, so you might need to over-allocate storage volume to obtain sufficient performance.
3. As with all user-provisioned installations, if you choose to use RHEL compute machines in your cluster, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks. Use of RHEL 7 compute machines is deprecated and has been removed in OpenShift Container Platform 4.10 and later.

If an instance type for your platform meets the minimum requirements for cluster machines, it is supported to use in OpenShift Container Platform.

Additional resources

- Optimizing storage

8.7.5.3. Tested instance types for GCP

The following Google Cloud Platform instance types have been tested with OpenShift Container Platform.

Example 8.23. Machine series

- **C2**
- **C2D**
- **C3**
- **E2**
- **M1**
- **N1**
- **N2**

- **N2D**
- **Tau T2D**

8.7.5.4. Using custom machine types

Using a custom machine type to install a OpenShift Container Platform cluster is supported.

Consider the following when using a custom machine type:

- Similar to predefined instance types, custom machine types must meet the minimum resource requirements for control plane and compute machines. For more information, see "Minimum resource requirements for cluster installation".
- The name of the custom machine type must adhere to the following syntax: **custom-<number_of_cpus>-<amount_of_memory_in_mb>**

  For example, **custom-6-20480**.

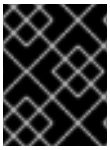
As part of the installation process, you specify the custom machine type in the **install-config.yaml** file.

Sample install-config.yaml file with a custom machine type

```
compute:
- architecture: amd64
  hyperthreading: Enabled
  name: worker
  platform:
    gcp:
      type: custom-6-20480
  replicas: 2
controlPlane:
  architecture: amd64
  hyperthreading: Enabled
  name: master
  platform:
    gcp:
      type: custom-6-20480
  replicas: 3
```

8.7.5.5. Sample customized install-config.yaml file for GCP

You can customize the **install-config.yaml** file to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.



IMPORTANT

This sample YAML file is provided for reference only. You must obtain your **install-config.yaml** file by using the installation program and modify it.

```
apiVersion: v1
baseDomain: example.com (1)
controlPlane: (2) (3)
```

```
  hyperthreading: Enabled 4
  name: master
  platform:
    gcp:
      type: n2-standard-4
      zones:
      - us-central1-a
      - us-central1-c
      osDisk:
        diskType: pd-ssd
        diskSizeGB: 1024
        encryptionKey: 5
          kmsKey:
            name: worker-key
            keyRing: test-machine-keys
            location: global
            projectID: project-id
        osImage: 6
          project: example-project-name
          name: example-image-name
  replicas: 3
compute: 7 8
- hyperthreading: Enabled 9
  name: worker
  platform:
    gcp:
      type: n2-standard-4
      zones:
      - us-central1-a
      - us-central1-c
      osDisk:
        diskType: pd-standard
        diskSizeGB: 128
        encryptionKey: 10
          kmsKey:
            name: worker-key
            keyRing: test-machine-keys
            location: global
            projectID: project-id
        osImage: 11
          project: example-project-name
          name: example-image-name
  replicas: 3
metadata:
  name: test-cluster 12
networking:
  clusterNetwork:
  - cidr: 10.128.0.0/14
    hostPrefix: 23
  machineNetwork:
  - cidr: 10.0.0.0/16
  networkType: OpenShiftSDN
  serviceNetwork:
  - 172.30.0.0/16
platform:
```

```
    gcp:
      projectID: openshift-production 13
      region: us-central1 14
      defaultMachinePlatform:
        osImage: 15
          project: example-project-name
          name: example-image-name
      network: existing_vpc 16
      controlPlaneSubnet: control_plane_subnet 17
      computeSubnet: compute_subnet 18
pullSecret: '{"auths":{"<local_registry>": {"auth": "<credentials>","email": "you@example.com"}}}' 19
fips: false 20
sshKey: ssh-ed25519 AAAA... 21
additionalTrustBundle: | 22
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
imageContentSources: 23
- mirrors:
  - <local_registry>/<local_repository_name>/release
  source: quay.io/openshift-release-dev/ocp-release
- mirrors:
  - <local_registry>/<local_repository_name>/release
  source: quay.io/openshift-release-dev/ocp-v4.0-art-dev
```

1 12 13 14 Required. The installation program prompts you for this value.

2 7 If you do not provide these parameters and values, the installation program provides the default value.

3 8 The **controlPlane** section is a single mapping, but the **compute** section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, **-**, and the first line of the **controlPlane** section must not. Only one control plane pool is used.

4 9 Whether to enable or disable simultaneous multithreading, or **hyperthreading**. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores. You can disable it by setting the parameter value to **Disabled**. If you disable simultaneous multithreading in some cluster machines, you must disable it in all cluster machines.

IMPORTANT

If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance. Use larger machine types, such as **n1-standard-8**, for your machines if you disable simultaneous multithreading.

5 10 Optional: The custom encryption key section to encrypt both virtual machines and persistent volumes. Your default compute service account must have the permissions granted to use your KMS key and have the correct IAM role assigned. The default service account name follows the **service-<project_number>@compute-system.iam.gserviceaccount.com** pattern. For more information on granting the correct permissions for your service account, see "Machine management" → "Creating machine sets" → "Creating a machine set on GCP".

6 11 15 Optional: A custom Red Hat Enterprise Linux CoreOS (RHCOS) image for the installation program to use to boot control plane and compute machines. The **project** and **name**

16 Specify the name of an existing VPC.

17 Specify the name of the existing subnet to deploy the control plane machines to. The subnet must belong to the VPC that you specified.

18 Specify the name of the existing subnet to deploy the compute machines to. The subnet must belong to the VPC that you specified.

19 For **<local_registry>**, specify the registry domain name, and optionally the port, that your mirror registry uses to serve content. For example, **registry.example.com** or **registry.example.com:5000**. For **<credentials>**, specify the base64-encoded user name and password for your mirror registry.

20 Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.

IMPORTANT

To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.

21 You can optionally provide the **sshKey** value that you use to access the machines in your cluster.

NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

22 Provide the contents of the certificate file that you used for your mirror registry.

23 Provide the **imageContentSources** section from the output of the command to mirror the repository.

8.7.5.6. Create an Ingress Controller with global access on GCP

You can create an Ingress Controller that has global access to a Google Cloud Platform (GCP) cluster. Global access is only available to Ingress Controllers using internal load balancers.

Prerequisites

- You created the **install-config.yaml** and complete any modifications to it.

Procedure

Create an Ingress Controller with global access on a new GCP cluster.

1. Change to the directory that contains the installation program and create a manifest file:

```
$ ./openshift-install create manifests --dir <installation_directory> 1
```

1 For **<installation_directory>**, specify the name of the directory that contains the **install-config.yaml** file for your cluster.

2. Create a file that is named **cluster-ingress-default-ingresscontroller.yaml** in the **<installation_directory>/manifests/** directory:

```
$ touch <installation_directory>/manifests/cluster-ingress-default-ingresscontroller.yaml 1
```

1 For **<installation_directory>**, specify the directory name that contains the **manifests/** directory for your cluster.

After creating the file, several network configuration files are in the **manifests/** directory, as shown:

```
$ ls <installation_directory>/manifests/cluster-ingress-default-ingresscontroller.yaml
```

Example output

```
cluster-ingress-default-ingresscontroller.yaml
```

3. Open the **cluster-ingress-default-ingresscontroller.yaml** file in an editor and enter a custom resource (CR) that describes the Operator configuration you want:

Sample clientAccess configuration to Global

```
apiVersion: operator.openshift.io/v1
kind: IngressController
metadata:
  name: default
  namespace: openshift-ingress-operator
spec:
  endpointPublishingStrategy:
    loadBalancer:
      providerParameters:
        gcp:
          clientAccess: Global 1
        type: GCP
      scope: Internal 2
    type: LoadBalancerService
```

1 Set **gcp.clientAccess** to **Global**.

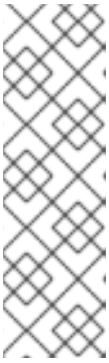
2 Global access is only available to Ingress Controllers using internal load balancers.

8.7.5.7. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.



NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
```

1. A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
2. A proxy URL to use for creating HTTPS connections outside the cluster.
3. A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use * to bypass the proxy for all destinations.
4. If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace that contains one or more additional CA certificates that are required for proxying HTTPS connections. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges these contents with the Red Hat

Enterprise Linux CoreOS (RHCOS) trust bundle, and this config map is referenced in the **trustedCA** field of the **Proxy** object. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.

NOTE

The installation program does not support the proxy **readinessEndpoints** field.

NOTE

If the installer times out, restart and then complete the deployment by using the **wait-for** command of the installer. For example:

```
$ ./openshift-install wait-for install-complete --log-level debug
```

2. Save the file and reference it when installing OpenShift Container Platform.

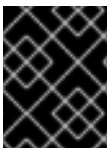
The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.

NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

8.7.6. Deploying the cluster

You can install OpenShift Container Platform on a compatible cloud platform.



IMPORTANT

You can run the **create cluster** command of the installation program only once, during initial installation.

Prerequisites

- Configure an account with the cloud platform that hosts your cluster.
- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.

Procedure

1. Remove any existing GCP credentials that do not use the service account key for the GCP account that you configured for your cluster and that are stored in the following locations:
   - The **GOOGLE_CREDENTIALS**, **GOOGLE_CLOUD_KEYFILE_JSON**, or **GCLOUD_KEYFILE_JSON** environment variables
   - The ~/**.gcp/osServiceAccount.json** file

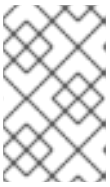
- The **gcloud cli** default credentials

2. Change to the directory that contains the installation program and initialize the cluster deployment:

```
$ ./openshift-install create cluster --dir <installation_directory> \ 1
    --log-level=info 2
```

1 For **<installation_directory>**, specify the location of your customized **./install-config.yaml** file.

2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.



NOTE

If the cloud provider account that you configured on your host does not have sufficient permissions to deploy the cluster, the installation process stops, and the missing permissions are displayed.

3. Optional: You can reduce the number of permissions for the service account that you used to install the cluster.

- If you assigned the **Owner** role to your service account, you can remove that role and replace it with the **Viewer** role.
- If you included the **Service Account Key Admin** role, you can remove it.

Verification

When the cluster deployment completes successfully:

- The terminal displays directions for accessing your cluster, including a link to the web console and credentials for the **kubeadmin** user.
- Credential information also outputs to **<installation_directory>/.openshift_install.log**.

IMPORTANT

Do not delete the installation program or the files that the installation program creates. Both are required to delete the cluster.

Example output

```
...
INFO Install complete!
INFO To access the cluster as the system:admin user when using 'oc', run 'export
KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
INFO Access the OpenShift web-console here: https://console-openshift-
console.apps.mycluster.example.com
INFO Login to the console with user: "kubeadmin", and password: "password"
INFO Time elapsed: 36m22s
```

IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

8.7.7. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.

IMPORTANT

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.11. Download and install the new version of **oc**.

Installing the OpenShift CLI on Linux
You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the architecture in the **Product Variant** drop-down menu.
3. Select the appropriate version in the **Version** drop-down menu.
4. Click **Download Now** next to the **OpenShift v4.11 Linux Client** entry and save the file.
5. Unpack the archive:

```
$ tar xvf <file>
```

6. Place the **oc** binary in a directory that is on your **PATH**.
   To check your **PATH**, execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

–

Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.
   To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

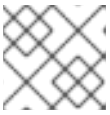
```
C:\> oc <command>
```

Installing the OpenShift CLI on macOS

You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 macOS Client** entry and save the file.



NOTE

For macOS arm64, choose the **OpenShift v4.11 macOS arm64 Client** entry.

4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your PATH.
   To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

8.7.8. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

Example output

```
system:admin
```

8.7.9. Disabling the default OperatorHub sources

Operator catalogs that source content provided by Red Hat and community projects are configured for OperatorHub by default during an OpenShift Container Platform installation. In a restricted network environment, you must disable the default catalogs as a cluster administrator.

Procedure

- Disable the sources for the default catalogs by adding **disableAllDefaultSources: true** to the **OperatorHub** object:

```
$ oc patch OperatorHub cluster --type json \
    -p '[{"op": "add", "path": "/spec/disableAllDefaultSources", "value": true}]'
```

TIP

Alternatively, you can use the web console to manage catalog sources. From the **Administration → Cluster Settings → Configuration → OperatorHub** page, click the **Sources** tab, where you can create, update, delete, disable, and enable individual sources.

8.7.10. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.11, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to OpenShift Cluster Manager Hybrid Cloud Console.

After you confirm that your OpenShift Cluster Manager Hybrid Cloud Console inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, use subscription watch to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

Additional resources

- See About remote health monitoring for more information about the Telemetry service

8.7.11. Next steps

- Validate an installation.
- Customize your cluster.
- Configure image streams for the Cluster Samples Operator and the **must-gather** tool.
- Learn how to use Operator Lifecycle Manager (OLM) on restricted networks .
- If the mirror registry that you used to install your cluster has a trusted CA, add it to the cluster by configuring additional trust stores.
- If necessary, you can opt out of remote health reporting .
- If necessary, see Registering your disconnected cluster

8.8. INSTALLING A CLUSTER ON GCP INTO AN EXISTING VPC

In OpenShift Container Platform version 4.11, you can install a cluster into an existing Virtual Private Cloud (VPC) on Google Cloud Platform (GCP). The installation program provisions the rest of the required infrastructure, which you can further customize. To customize the installation, you modify parameters in the **install-config.yaml** file before you install the cluster.

8.8.1. Prerequisites

- You reviewed details about the OpenShift Container Platform installation and update processes.
- You read the documentation on selecting a cluster installation method and preparing it for users.
- You configured a GCP project to host the cluster.
- If you use a firewall, you configured it to allow the sites that your cluster requires access to.
- If the cloud identity and access management (IAM) APIs are not accessible in your environment, or if you do not want to store an administrator-level credential secret in the **kube-system** namespace, you can manually create and maintain IAM credentials .

8.8.2. About using a custom VPC

In OpenShift Container Platform 4.11, you can deploy a cluster into existing subnets in an existing Virtual Private Cloud (VPC) in Google Cloud Platform (GCP). By deploying OpenShift Container Platform into an existing GCP VPC, you might be able to avoid limit constraints in new accounts or more easily abide by the operational constraints that your company's guidelines set. If you cannot obtain the infrastructure creation permissions that are required to create the VPC yourself, use this installation option. You must configure networking for the subnets.

8.8.2.1. Requirements for using your VPC

The union of the VPC CIDR block and the machine network CIDR must be non-empty. The subnets must be within the machine network.

The installation program does not create the following components:

- NAT gateways
- Subnets
- Route tables
- VPC network

NOTE

The installation program requires that you use the cloud-provided DNS server. Using a custom DNS server is not supported and causes the installation to fail.

8.8.2.2. VPC validation

To ensure that the subnets that you provide are suitable, the installation program confirms the following data:

- All the subnets that you specify exist.
- You provide one subnet for control-plane machines and one subnet for compute machines.
- The subnet's CIDRs belong to the machine CIDR that you specified.

8.8.2.3. Division of permissions

Some individuals can create different resource in your clouds than others. For example, you might be able to create application-specific items, like instances, buckets, and load balancers, but not networking-related components such as VPCs, subnets, or ingress rules.

8.8.2.4. Isolation between clusters

If you deploy OpenShift Container Platform to an existing network, the isolation of cluster services is reduced in the following ways:

- You can install multiple OpenShift Container Platform clusters in the same VPC.
- ICMP ingress is allowed to the entire network.

- TCP 22 ingress (SSH) is allowed to the entire network.
- Control plane TCP 6443 ingress (Kubernetes API) is allowed to the entire network.
- Control plane TCP 22623 ingress (MCS) is allowed to the entire network.

8.8.3. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.11, you require access to the internet to install your cluster.

You must have internet access to:

- Access OpenShift Cluster Manager Hybrid Cloud Console to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access Quay.io to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.

IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

8.8.4. Generating a key pair for cluster node SSH access

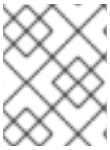
During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the **~/.ssh/authorized_keys** list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The **./openshift-install gather** command also requires the SSH public key to be in place on the cluster nodes.

IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.



NOTE

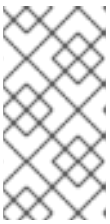
You must use a local key, not one that you configured with platform-specific approaches such as AWS key pairs.

Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N '' -f <path>/<file_name> 1
```

1 Specify the path and file name, such as ~/**.ssh/id_ed25519**, of the new SSH key. If you have an existing key pair, ensure your public key is in the your ~/**.ssh** directory.



NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS validated or Modules In Process cryptographic libraries on the **x86_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the ~/**.ssh/id_ed25519.pub** public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the **./openshift-install gather** command.

NOTE

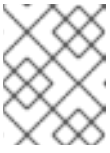
On some distributions, default SSH private key identities such as ~/**.ssh/id_rsa** and ~/**.ssh/id_dsa** are managed automatically.

a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

Example output

```
Agent pid 31874
```



NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

1 Specify the path and file name for your SSH private key, such as **~/.ssh/id_ed25519**

Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

5. Set the **GOOGLE_APPLICATION_CREDENTIALS** environment variable to the full path to your service account private key file.

```
$ export GOOGLE_APPLICATION_CREDENTIALS="<your_service_account_file>"
```

6. Verify that the credentials were applied.

```
$ gcloud auth list
```

Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

8.8.5. Obtaining the installation program

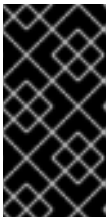
Before you install OpenShift Container Platform, download the installation file on a local computer.

Prerequisites

- You have a computer that runs Linux or macOS, with 500 MB of local disk space.

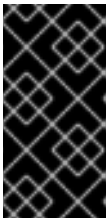
Procedure

1. Access the Infrastructure Provider page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program that corresponds with your host operating system and architecture, and place the file in the directory where you will store the installation configuration files.



IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.



IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation pull secret from the Red Hat OpenShift Cluster Manager . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

8.8.6. Creating the installation configuration file

You can customize the OpenShift Container Platform cluster you install on Google Cloud Platform (GCP).

Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.
- Obtain service principal permissions at the subscription level.

Procedure

1. Create the **install-config.yaml** file.
   a. Change to the directory that contains the installation program and run the following command:

```
$ ./openshift-install create install-config --dir <installation_directory> 1
```

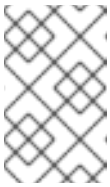
   1 For **<installation_directory>**, specify the directory name to store the files that the installation program creates.

   When specifying the directory:

   - Verify that the directory has the **execute** permission. This permission is required to run Terraform binaries under the installation directory.
   - Use an empty directory. Some installation assets, such as bootstrap X.509 certificates, have short expiration intervals, therefore you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

   b. At the prompts, provide the configuration details for your cloud:

i. Optional: Select an SSH key to use to access your cluster machines.



NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

ii. Select **gcp** as the platform to target.

iii. If you have not configured the service account key for your GCP account on your computer, you must obtain it from GCP and paste the contents of the file or enter the absolute path to the file.

iv. Select the project ID to provision the cluster in. The default value is specified by the service account that you configured.

v. Select the region to deploy the cluster to.

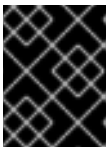
vi. Select the base domain to deploy the cluster to. The base domain corresponds to the public DNS zone that you created for your cluster.

vii. Enter a descriptive name for your cluster.

viii. Paste the pull secret from the Red Hat OpenShift Cluster Manager .

2. Modify the **install-config.yaml** file. You can find more information about the available parameters in the "Installation configuration parameters" section.

3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.



IMPORTANT

The **install-config.yaml** file is consumed during the installation process. If you want to reuse the file, you must back it up now.

8.8.6.1. Installation configuration parameters

Before you deploy an OpenShift Container Platform cluster, you provide parameter values to describe your account on the cloud platform that hosts your cluster and optionally customize your cluster's platform. When you create the **install-config.yaml** installation configuration file, you provide values for the required parameters through the command line. If you customize your cluster, you can modify the **install-config.yaml** file to provide more details about the platform.

NOTE

After installation, you cannot modify these parameters in the **install-config.yaml** file.

8.8.6.1.1. Required configuration parameters

Required installation configuration parameters are described in the following table:

Table 8.27. Required parameters

Parameter	Description	Values
apiVersion	The API version for the **install-config.yaml** content. The current version is **v1**. The installer may also support older API versions.	String
baseDomain	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the **baseDomain** and **metadata.name** parameter values that uses the **<metadata.name>.<baseDomain>** format.	A fully-qualified domain or subdomain name, such as **example.com**.
metadata	Kubernetes resource **ObjectMeta**, from which only the **name** parameter is consumed.	Object
metadata.name	The name of the cluster. DNS records for the cluster are all subdomains of **{{.metadata.name}}.{{.baseDomain}}**.	String of lowercase letters, hyphens (**-**), and periods (**.**), such as **dev**.
platform	The configuration for the specific platform upon which to perform the installation: **alibabacloud**, **aws**, **baremetal**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**. For additional information about **platform.<platform>** parameters, consult the table for your specific platform that follows.	Object

Parameter	Description	Values
pullSecret	Get a pull secret from the Red Hat OpenShift Cluster Manager to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	<pre>{ "auths":{ "cloud.openshift.com":{ "auth":"b3Blb=", "email":"you@example.com" }, "quay.io":{ "auth":"b3Blb=", "email":"you@example.com" } } }</pre>

8.8.6.1.2. Network configuration parameters

You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

Only IPv4 addresses are supported.

NOTE

Globalnet is not supported with Red Hat OpenShift Data Foundation disaster recovery solutions. For regional disaster recovery scenarios, ensure that you use a nonoverlapping range of private IP addresses for the cluster and service networks in each cluster.

Table 8.28. Network parameters

Parameter	Description	Values
networking	The configuration for the cluster network.	Object  **NOTE** You cannot modify parameters specified by the **networking** object after installation.

Parameter	Description	Values
networking.networkType	The cluster network provider Container Network Interface (CNI) cluster network provider to install.	Either **OpenShiftSDN** or **OVNKubernetes**. **OpenShiftSDN** is a CNI provider for all-Linux networks. **OVNKubernetes** is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is **OpenShiftSDN**.
networking.clusterNetwork	The IP address blocks for pods. The default value is **10.128.0.0/14** with a host prefix of **/23**. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: ``` networking: clusterNetwork: - cidr: 10.128.0.0/14 hostPrefix: 23 ```
networking.clusterNetwork.cidr	Required if you use **networking.clusterNetwork**. An IP address block. An IPv4 network.	An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between **0** and **32**.
networking.clusterNetwork.hostPrefix	The subnet prefix length to assign to each individual node. For example, if **hostPrefix** is set to **23** then each node is assigned a **/23** subnet out of the given **cidr**. A **hostPrefix** value of **23** provides 510 (2^(32 - 23) - 2) pod IP addresses.	A subnet prefix. The default value is **23**.
networking.serviceNetwork	The IP address block for services. The default value is **172.30.0.0/16**. The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.	An array with an IP address block in CIDR format. For example: ``` networking: serviceNetwork: - 172.30.0.0/16 ```
networking.machineNetwork	The IP address blocks for machines. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: ``` networking: machineNetwork: - cidr: 10.0.0.0/16 ```

Parameter	Description	Values
networking.machineNetwork.cidr	Required if you use **networking.machineNetwork**. An IP address block. The default value is **10.0.0.0/16** for all platforms other than libvirt. For libvirt, the default value is **192.168.126.0/24**.	An IP network block in CIDR notation. For example, **10.0.0.0/16**.  **NOTE** Set the **networking.machineNetwork** to match the CIDR that the preferred NIC resides in.

8.8.6.1.3. Optional configuration parameters

Optional installation configuration parameters are described in the following table:

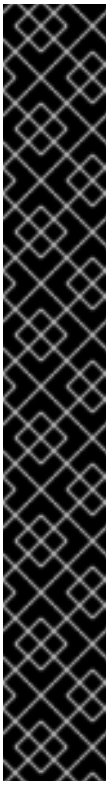
Table 8.29. Optional parameters

Parameter	Description	Values
additionalTrustBundle	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String
capabilities	Controls the installation of optional core cluster components. You can reduce the footprint of your OpenShift Container Platform cluster by disabling optional components.	String array
capabilities.baselineCapabilitySet	Selects an initial set of optional capabilities to enable. Valid values are **None**, **v4.11** and **vCurrent**. **v4.11** enables the **baremetal** Operator, the **marketplace** Operator, and the **openshift-samples** content. **vCurrent** installs the recommended set of capabilities for the current version of OpenShift Container Platform. The default value is **vCurrent**.	String

Parameter	Description	Values
capabilities.additionalEnabledCapabilities	Extends the set of optional capabilities beyond what you specify in **baselineCapabilitySet**. Valid values are **baremetal**, **marketplace** and **openshift-samples**. You may specify multiple capabilities in this parameter.	String array
cgroupsV2	Enables Linux control groups version 2 (cgroups v2) on specific nodes in your cluster. The OpenShift Container Platform process for enabling cgroups v2 disables all cgroup version 1 controllers and hierarchies. The OpenShift Container Platform cgroups version 2 feature is in Developer Preview and is not supported by Red Hat at this time.	**true**
compute	The configuration for the machines that comprise the compute nodes.	Array of **MachinePool** objects.
compute.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** (the default).	String
compute.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  IMPORTANT If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
compute.name	Required if you use **compute**. The name of the machine pool.	**worker**

Parameter	Description	Values
compute.platform	Required if you use **compute**. Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the **controlPlane.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
compute.replicas	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to **2**. The default value is **3**.
controlPlane	The configuration for the machines that comprise the control plane.	Array of **MachinePool** objects.
controlPlane.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** (the default).	String
controlPlane.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  IMPORTANT If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
controlPlane.name	Required if you use **controlPlane**. The name of the machine pool.	**master**

Parameter	Description	Values
controlPlane.platform	Required if you use **controlPlane**. Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the **compute.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
controlPlane.replicas	The number of control plane machines to provision.	The only supported value is **3**, which is the default value.
credentialsMode	The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported. If you are installing on GCP into a shared virtual private cloud (VPC), **credentialsMode** must be set to **Passthrough**.  NOTE Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the *Cloud Credential Operator* entry in the *Cluster Operators reference* content.  NOTE If your AWS account has service control policies (SCP) enabled, you must configure the **credentialsMode** parameter to **Mint**, **Passthrough** or **Manual**.	**Mint**, **Passthrough**, **Manual** or an empty string (**""**).
fips	Enable or disable FIPS mode. The default is **false** (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default	**false** or **true**

Parameter	Description	Values
	Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.  **IMPORTANT** To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.  **NOTE** If you are using Azure File storage, you cannot enable FIPS mode.	

Parameter	Description	Values
imageContentSources	Sources and repositories for the release-image content.	Array of objects. Includes a **source** and, optionally, **mirrors**, as described in the following rows of this table.
imageContentSources.source	Required if you use **imageContentSources**. Specify the repository that users refer to, for example, in image pull specifications.	String
imageContentSources.mirrors	Specify one or more repositories that may also contain the same images.	Array of strings
publish	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	**Internal** or **External**. To deploy a private cluster, which cannot be accessed from the internet, set **publish** to **Internal**. The default value is **External**.
sshKey	The SSH key to authenticate access to your cluster machines.  NOTE For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.	For example, **sshKey: ssh-ed25519 AAAA..**.

8.8.6.1.4. Additional Google Cloud Platform (GCP) configuration parameters

Additional GCP configuration parameters are described in the following table:

Table 8.30. Additional GCP parameters

Parameter	Description	Values
platform.gcp.network	The name of the existing VPC that you want to deploy your cluster to.	String.

Parameter	Description	Values
platform.gcp.projectID	The name of the GCP project where the installation program installs the cluster.	String.
platform.gcp.region	The name of the GCP region that hosts your cluster.	Any valid region name, such as **us-central1**.
platform.gcp.controlPlaneSubnet	The name of the existing subnet in your VPC that you want to deploy your control plane machines to.	The subnet name.
platform.gcp.computeSubnet	The name of the existing subnet in your VPC that you want to deploy your compute machines to.	The subnet name.
platform.gcp.licenses	A list of license URLs that must be applied to the compute images.  **IMPORTANT** The **licenses** parameter is a deprecated field and nested virtualization is enabled by default. It is not recommended to use this field.	Any license available with the license API, such as the license to enable nested virtualization. You cannot use this parameter with a mechanism that generates pre-built images. Using a license URL forces the installer to copy the source image before use.
platform.gcp.defaultMachinePlatform.osDisk.diskSizeGB	The size of the disk in gigabytes (GB).	Any size between 16 GB and 65536 GB.

Parameter	Description	Values
platform.gcp.defaultMachinePlatform.osDisk.diskType	The type of disk.	Either the default **pd-ssd** or the **pd-standard** disk type. The control plane nodes must be the **pd-ssd** disk type. The worker nodes can be either type.
platform.gcp.defaultMachinePlatform.osImage.project	Optional. By default, the installation program downloads and installs the RHCOS image that is used to boot control plane and compute machines. You can override the default behavior by specifying the location of a custom RHCOS image for the installation program to use for both types of machines.	String. The name of GCP project where the image is located.
platform.gcp.defaultMachinePlatform.osImage.name	The name of the custom RHCOS image for the installation program to use to boot control plane and compute machines. If you use **platform.gcp.defaultMachinePlatform.osImage.project**, this field is required.	String. The name of the RHCOS image.
platform.gcp.defaultMachinePlatform.type	The GCP machine type.	The GCP machine type.
platform.gcp.defaultMachinePlatform.zones	The availability zones where the installation program creates machines for the specified MachinePool.	A list of valid GCP availability zones, such as **us-central1-a**, in a YAML sequence.

Parameter	Description	Values
controlPlane.platform.gcp.osDisk.encryptionKey.kmsKey.name	The name of the customer managed encryption key to be used for control plane machine disk encryption.	The encryption key name.
controlPlane.platform.gcp.osDisk.encryptionKey.kmsKey.keyRing	For control plane machines, the name of the KMS key ring to which the KMS key belongs.	The KMS key ring name.
controlPlane.platform.gcp.osDisk.encryptionKey.kmsKey.location	For control plane machines, the GCP location in which the key ring exists. For more information on KMS locations, see Google's documentation on Cloud KMS locations.	The GCP location for the key ring.
controlPlane.platform.gcp.osDisk.encryptionKey.kmsKey.projectID	For control plane machines, the ID of the project in which the KMS key ring exists. This value defaults to the VM project ID if not set.	The GCP project ID.

Parameter	Description	Values
controlPlane.platform.gcp.osImage.project	Optional. By default, the installation program downloads and installs the Red Hat Enterprise Linux CoreOS (RHCOS) image that is used to boot control plane machines. You can override the default behavior by specifying the location of a custom RHCOS image for the installation program to use for control plane machines only.	String. The name of GCP project where the image is located.
controlPlane.platform.gcp.osImage.name	The name of the custom RHCOS image for the installation program to use to boot control plane machines. If you use **controlPlane.platform.gcp.osImage.project**, this field is required.	String. The name of the RHCOS image.
compute.platform.gcp.osDisk.encryptionKey.kmsKey.name	The name of the customer managed encryption key to be used for compute machine disk encryption.	The encryption key name.
compute.platform.gcp.osDisk.encryptionKey.kmsKey.keyRing	For compute machines, the name of the KMS key ring to which the KMS key belongs.	The KMS key ring name.

Parameter	Description	Values
compute.platform.gcp.osDisk.encryptionKey.kmsKey.location	For compute machines, the GCP location in which the key ring exists. For more information on KMS locations, see Google's documentation on Cloud KMS locations.	The GCP location for the key ring.
compute.platform.gcp.osDisk.encryptionKey.kmsKey.projectID	For compute machines, the ID of the project in which the KMS key ring exists. This value defaults to the VM project ID if not set.	The GCP project ID.
compute.platform.gcp.osImage.project	Optional. By default, the installation program downloads and installs the RHCOS image that is used to boot compute machines. You can override the default behavior by specifying the location of a custom RHCOS image for the installation program to use for compute machines only.	String. The name of GCP project where the image is located.
compute.platform.gcp.osImage.name	The name of the custom RHCOS image for the installation program to use to boot compute machines. If you use **compute.platform.gcp.osImage.project**, this field is required.	String. The name of the RHCOS image.

8.8.6.2. Minimum resource requirements for cluster installation

Each cluster machine must meet the following minimum requirements:

Table 8.31. Minimum resource requirements

Machine	Operating System	vCPU [1]	Virtual RAM	Storage	IOPS [2]
Bootstrap	RHCOS	4	16 GB	100 GB	300
Control plane	RHCOS	4	16 GB	100 GB	300
Compute	RHCOS, RHEL 8.6 and later [3]	2	8 GB	100 GB	300

1. One vCPU is equivalent to one physical core when simultaneous multithreading (SMT), or hyperthreading, is not enabled. When enabled, use the following formula to calculate the corresponding ratio: (threads per core × cores) × sockets = vCPUs.

2. OpenShift Container Platform and Kubernetes are sensitive to disk performance, and faster storage is recommended, particularly for etcd on the control plane nodes which require a 10 ms p99 fsync duration. Note that on many cloud platforms, storage size and IOPS scale together, so you might need to over-allocate storage volume to obtain sufficient performance.

3. As with all user-provisioned installations, if you choose to use RHEL compute machines in your cluster, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks. Use of RHEL 7 compute machines is deprecated and has been removed in OpenShift Container Platform 4.10 and later.

If an instance type for your platform meets the minimum requirements for cluster machines, it is supported to use in OpenShift Container Platform.

Additional resources

- Optimizing storage

8.8.6.3. Tested instance types for GCP

The following Google Cloud Platform instance types have been tested with OpenShift Container Platform.

> **Example 8.24. Machine series**
>
> - **C2**
> - **C2D**
> - **C3**
> - **E2**
> - **M1**
> - **N1**
> - **N2**

- **N2D**
- **Tau T2D**

8.8.6.4. Using custom machine types

Using a custom machine type to install a OpenShift Container Platform cluster is supported.

Consider the following when using a custom machine type:

- Similar to predefined instance types, custom machine types must meet the minimum resource requirements for control plane and compute machines. For more information, see "Minimum resource requirements for cluster installation".
- The name of the custom machine type must adhere to the following syntax: **custom-<number_of_cpus>-<amount_of_memory_in_mb>**

  For example, **custom-6-20480**.

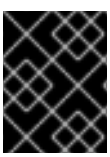
As part of the installation process, you specify the custom machine type in the **install-config.yaml** file.

Sample install-config.yaml file with a custom machine type

```
compute:
- architecture: amd64
  hyperthreading: Enabled
  name: worker
  platform:
    gcp:
      type: custom-6-20480
  replicas: 2
controlPlane:
  architecture: amd64
  hyperthreading: Enabled
  name: master
  platform:
    gcp:
      type: custom-6-20480
  replicas: 3
```

8.8.6.5. Sample customized install-config.yaml file for GCP

You can customize the **install-config.yaml** file to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.



IMPORTANT

This sample YAML file is provided for reference only. You must obtain your **install-config.yaml** file by using the installation program and modify it.

```
apiVersion: v1
baseDomain: example.com (1)
controlPlane: (2) (3)
```

```
  hyperthreading: Enabled 4
  name: master
  platform:
    gcp:
      type: n2-standard-4
      zones:
      - us-central1-a
      - us-central1-c
      osDisk:
        diskType: pd-ssd
        diskSizeGB: 1024
        encryptionKey: 5
          kmsKey:
            name: worker-key
            keyRing: test-machine-keys
            location: global
            projectID: project-id
        osImage: 6
          project: example-project-name
          name: example-image-name
  replicas: 3
compute: 7 8
- hyperthreading: Enabled 9
  name: worker
  platform:
    gcp:
      type: n2-standard-4
      zones:
      - us-central1-a
      - us-central1-c
      osDisk:
        diskType: pd-standard
        diskSizeGB: 128
        encryptionKey: 10
          kmsKey:
            name: worker-key
            keyRing: test-machine-keys
            location: global
            projectID: project-id
        osImage: 11
          project: example-project-name
          name: example-image-name
  replicas: 3
metadata:
  name: test-cluster 12
networking:
  clusterNetwork:
  - cidr: 10.128.0.0/14
    hostPrefix: 23
  machineNetwork:
  - cidr: 10.0.0.0/16
  networkType: OpenShiftSDN
  serviceNetwork:
  - 172.30.0.0/16
platform:
```

```
    gcp:
      projectID: openshift-production 13
      region: us-central1 14
      defaultMachinePlatform:
        osImage: 15
          project: example-project-name
          name: example-image-name
      network: existing_vpc 16
      controlPlaneSubnet: control_plane_subnet 17
      computeSubnet: compute_subnet 18
  pullSecret: '{"auths": ...}' 19
  fips: false 20
  sshKey: ssh-ed25519 AAAA... 21
```

1 12 13 14 19 Required. The installation program prompts you for this value.

2 7 If you do not provide these parameters and values, the installation program provides the default value.

3 8 The **controlPlane** section is a single mapping, but the **compute** section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, **-**, and the first line of the **controlPlane** section must not. Only one control plane pool is used.

4 9 Whether to enable or disable simultaneous multithreading, or **hyperthreading**. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores. You can disable it by setting the parameter value to **Disabled**. If you disable simultaneous multithreading in some cluster machines, you must disable it in all cluster machines.

IMPORTANT

If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance. Use larger machine types, such as **n1-standard-8**, for your machines if you disable simultaneous multithreading.

5 10 Optional: The custom encryption key section to encrypt both virtual machines and persistent volumes. Your default compute service account must have the permissions granted to use your KMS key and have the correct IAM role assigned. The default service account name follows the **service-<project_number>@compute-system.iam.gserviceaccount.com** pattern. For more information on granting the correct permissions for your service account, see "Machine management" → "Creating machine sets" → "Creating a machine set on GCP".

6 11 15 Optional: A custom Red Hat Enterprise Linux CoreOS (RHCOS) image for the installation program to use to boot control plane and compute machines. The **project** and **name** parameters under **platform.gcp.defaultMachinePlatform.osImage** apply to both control plane and compute machines. If the **project** and **name** parameters under **controlPlane.platform.gcp.osImage** or **compute.platform.gcp.osImage** are set, they override the **platform.gcp.defaultMachinePlatform.osImage** parameters.

16 Specify the name of an existing VPC.

17 Specify the name of the existing subnet to deploy the control plane machines to. The subnet must belong to the VPC that you specified.

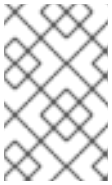
18 Specify the name of the existing subnet to deploy the compute machines to. The subnet must belong to the VPC that you specified.

20 Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.

IMPORTANT

To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.

21 You can optionally provide the **sshKey** value that you use to access the machines in your cluster.



NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

8.8.6.6. Create an Ingress Controller with global access on GCP

You can create an Ingress Controller that has global access to a Google Cloud Platform (GCP) cluster. Global access is only available to Ingress Controllers using internal load balancers.

Prerequisites

- You created the **install-config.yaml** and complete any modifications to it.

Procedure

Create an Ingress Controller with global access on a new GCP cluster.

1. Change to the directory that contains the installation program and create a manifest file:

```
$ ./openshift-install create manifests --dir <installation_directory> 1
```

1 For **<installation_directory>**, specify the name of the directory that contains the **install-config.yaml** file for your cluster.

2. Create a file that is named **cluster-ingress-default-ingresscontroller.yaml** in the **<installation_directory>/manifests/** directory:

```
$ touch <installation_directory>/manifests/cluster-ingress-default-ingresscontroller.yaml 1
```

1 For **<installation_directory>**, specify the directory name that contains the **manifests/** directory for your cluster.

After creating the file, several network configuration files are in the **manifests/** directory, as shown:

```
$ ls <installation_directory>/manifests/cluster-ingress-default-ingresscontroller.yaml
```

Example output

```
cluster-ingress-default-ingresscontroller.yaml
```

3. Open the **cluster-ingress-default-ingresscontroller.yaml** file in an editor and enter a custom resource (CR) that describes the Operator configuration you want:

Sample clientAccess configuration to Global

```
apiVersion: operator.openshift.io/v1
kind: IngressController
metadata:
  name: default
  namespace: openshift-ingress-operator
spec:
  endpointPublishingStrategy:
    loadBalancer:
      providerParameters:
        gcp:
          clientAccess: Global 1
        type: GCP
      scope: Internal 2
    type: LoadBalancerService
```

1. Set **gcp.clientAccess** to **Global**.
2. Global access is only available to Ingress Controllers using internal load balancers.

8.8.7. Additional resources

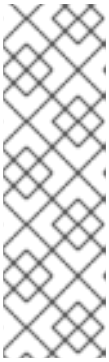
- Enabling customer-managed encryption keys for a machine set

8.8.7.1. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.



NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
```

1. A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
2. A proxy URL to use for creating HTTPS connections outside the cluster.
3. A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use ***** to bypass the proxy for all destinations.
4. If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace that contains one or more additional CA certificates that are required for proxying HTTPS connections. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges these contents with the Red Hat Enterprise Linux CoreOS (RHCOS) trust bundle, and this config map is referenced in the **trustedCA** field of the **Proxy** object. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.

NOTE

The installation program does not support the proxy **readinessEndpoints** field.

NOTE

If the installer times out, restart and then complete the deployment by using the **wait-for** command of the installer. For example:

```
$ ./openshift-install wait-for install-complete --log-level debug
```

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.

NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

8.8.8. Deploying the cluster

You can install OpenShift Container Platform on a compatible cloud platform.

IMPORTANT

You can run the **create cluster** command of the installation program only once, during initial installation.

Prerequisites

- Configure an account with the cloud platform that hosts your cluster.
- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.

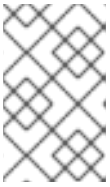
Procedure

1. Remove any existing GCP credentials that do not use the service account key for the GCP account that you configured for your cluster and that are stored in the following locations:
   - The **GOOGLE_CREDENTIALS**, **GOOGLE_CLOUD_KEYFILE_JSON**, or **GCLOUD_KEYFILE_JSON** environment variables
   - The **~/.gcp/osServiceAccount.json** file
   - The **gcloud cli** default credentials
2. Change to the directory that contains the installation program and initialize the cluster deployment:

```
$ ./openshift-install create cluster --dir <installation_directory> \ 1
    --log-level=info 2
```

1 For **<installation_directory>**, specify the location of your customized **./install-config.yaml** file.

2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.



NOTE

If the cloud provider account that you configured on your host does not have sufficient permissions to deploy the cluster, the installation process stops, and the missing permissions are displayed.

3. Optional: You can reduce the number of permissions for the service account that you used to install the cluster.
   - If you assigned the **Owner** role to your service account, you can remove that role and replace it with the **Viewer** role.
   - If you included the **Service Account Key Admin** role, you can remove it.

Verification

When the cluster deployment completes successfully:

- The terminal displays directions for accessing your cluster, including a link to the web console and credentials for the **kubeadmin** user.
- Credential information also outputs to **<installation_directory>/.openshift_install.log**.

IMPORTANT

Do not delete the installation program or the files that the installation program creates. Both are required to delete the cluster.

Example output

```
...
INFO Install complete!
INFO To access the cluster as the system:admin user when using 'oc', run 'export
KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
INFO Access the OpenShift web-console here: https://console-openshift-
console.apps.mycluster.example.com
INFO Login to the console with user: "kubeadmin", and password: "password"
INFO Time elapsed: 36m22s
```

IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

8.8.9. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.

IMPORTANT

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.11. Download and install the new version of **oc**.

Installing the OpenShift CLI on Linux
You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the architecture in the **Product Variant** drop-down menu.
3. Select the appropriate version in the **Version** drop-down menu.
4. Click **Download Now** next to the **OpenShift v4.11 Linux Client** entry and save the file.
5. Unpack the archive:

```
$ tar xvf <file>
```

6. Place the **oc** binary in a directory that is on your **PATH**.
   To check your **PATH**, execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

–

Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.
   To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
C:\> oc <command>
```

Installing the OpenShift CLI on macOS

You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 macOS Client** entry and save the file.

NOTE

For macOS arm64, choose the **OpenShift v4.11 macOS arm64 Client** entry.

4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your PATH.
   To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

8.8.10. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

Example output

```
system:admin
```

Additional resources

- See Accessing the web console for more details about accessing and understanding the OpenShift Container Platform web console.

8.8.11. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.11, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to OpenShift Cluster Manager Hybrid Cloud Console.

After you confirm that your OpenShift Cluster Manager Hybrid Cloud Console inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, use subscription watch to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

Additional resources

- See About remote health monitoring for more information about the Telemetry service

8.8.12. Next steps

- Customize your cluster.
- If necessary, you can opt out of remote health reporting .

8.9. INSTALLING A PRIVATE CLUSTER ON GCP

In OpenShift Container Platform version 4.11, you can install a private cluster into an existing VPC on Google Cloud Platform (GCP). The installation program provisions the rest of the required infrastructure, which you can further customize. To customize the installation, you modify parameters in the **install-config.yaml** file before you install the cluster.

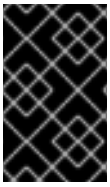
8.9.1. Prerequisites

- You reviewed details about the OpenShift Container Platform installation and update processes.
- You read the documentation on selecting a cluster installation method and preparing it for users.
- You configured a GCP project to host the cluster.
- If you use a firewall, you configured it to allow the sites that your cluster requires access to.
- If the cloud identity and access management (IAM) APIs are not accessible in your environment, or if you do not want to store an administrator-level credential secret in the **kube-system** namespace, you can manually create and maintain IAM credentials.

8.9.2. Private clusters

You can deploy a private OpenShift Container Platform cluster that does not expose external endpoints. Private clusters are accessible from only an internal network and are not visible to the internet.

By default, OpenShift Container Platform is provisioned to use publicly-accessible DNS and endpoints. A private cluster sets the DNS, Ingress Controller, and API server to private when you deploy your cluster. This means that the cluster resources are only accessible from your internal network and are not visible to the internet.



IMPORTANT

If the cluster has any public subnets, load balancer services created by administrators might be publicly accessible. To ensure cluster security, verify that these services are explicitly annotated as private.

To deploy a private cluster, you must:

- Use existing networking that meets your requirements. Your cluster resources might be shared between other clusters on the network.
- Deploy from a machine that has access to:
  - The API services for the cloud to which you provision.

- The hosts on the network that you provision.
- The internet to obtain installation media.

You can use any machine that meets these access requirements and follows your company's guidelines. For example, this machine can be a bastion host on your cloud network or a machine that has access to the network through a VPN.

8.9.2.1. Private clusters in GCP

To create a private cluster on Google Cloud Platform (GCP), you must provide an existing private VPC and subnets to host the cluster. The installation program must also be able to resolve the DNS records that the cluster requires. The installation program configures the Ingress Operator and API server for only internal traffic.

The cluster still requires access to internet to access the GCP APIs.

The following items are not required or created when you install a private cluster:

- Public subnets
- Public network load balancers, which support public ingress
- A public DNS zone that matches the **baseDomain** for the cluster

The installation program does use the **baseDomain** that you specify to create a private DNS zone and the required records for the cluster. The cluster is configured so that the Operators do not create public records for the cluster and all cluster machines are placed in the private subnets that you specify.

Because it is not possible to limit access to external load balancers based on source tags, the private cluster uses only internal load balancers to allow access to internal instances.

The internal load balancer relies on instance groups rather than the target pools that the network load balancers use. The installation program creates instance groups for each zone, even if there is no instance in that group.

- The cluster IP address is internal only.
- One forwarding rule manages both the Kubernetes API and machine config server ports.
- The backend service is comprised of each zone's instance group and, while it exists, the bootstrap instance group.
- The firewall uses a single rule that is based on only internal source ranges.

8.9.2.1.1. Limitations

No health check for the Machine config server, /**healthz**, runs because of a difference in load balancer functionality. Two internal load balancers cannot share a single IP address, but two network load balancers can share a single external IP address. Instead, the health of an instance is determined entirely by the /**readyz** check on port 6443.

8.9.3. About using a custom VPC

In OpenShift Container Platform 4.11, you can deploy a cluster into an existing VPC in Google Cloud Platform (GCP). If you do, you must also use existing subnets within the VPC and routing rules.

By deploying OpenShift Container Platform into an existing GCP VPC, you might be able to avoid limit constraints in new accounts or more easily abide by the operational constraints that your company's guidelines set. This is a good option to use if you cannot obtain the infrastructure creation permissions that are required to create the VPC yourself.

8.9.3.1. Requirements for using your VPC

The installation program will no longer create the following components:

- VPC
- Subnets
- Cloud router
- Cloud NAT
- NAT IP addresses

If you use a custom VPC, you must correctly configure it and its subnets for the installation program and the cluster to use. The installation program cannot subdivide network ranges for the cluster to use, set route tables for the subnets, or set VPC options like DHCP, so you must do so before you install the cluster.

Your VPC and subnets must meet the following characteristics:

- The VPC must be in the same GCP project that you deploy the OpenShift Container Platform cluster to.
- To allow access to the internet from the control plane and compute machines, you must configure cloud NAT on the subnets to allow egress to it. These machines do not have a public address. Even if you do not require access to the internet, you must allow egress to the VPC network to obtain the installation program and images. Because multiple cloud NATs cannot be configured on the shared subnets, the installation program cannot configure it.

To ensure that the subnets that you provide are suitable, the installation program confirms the following data:

- All the subnets that you specify exist and belong to the VPC that you specified.
- The subnet CIDRs belong to the machine CIDR.
- You must provide a subnet to deploy the cluster control plane and compute machines to. You can use the same subnet for both machine types.

If you destroy a cluster that uses an existing VPC, the VPC is not deleted.

8.9.3.2. Division of permissions

Starting with OpenShift Container Platform 4.3, you do not need all of the permissions that are required for an installation program-provisioned infrastructure cluster to deploy a cluster. This change mimics the division of permissions that you might have at your company: some individuals can create different resources in your clouds than others. For example, you might be able to create application-specific items, like instances, buckets, and load balancers, but not networking-related components such as VPCs, subnets, or Ingress rules.

The GCP credentials that you use when you create your cluster do not need the networking permissions

that are required to make VPCs and core networking components within the VPC, such as subnets, routing tables, internet gateways, NAT, and VPN. You still need permission to make the application resources that the machines within the cluster require, such as load balancers, security groups, storage, and nodes.

8.9.3.3. Isolation between clusters

If you deploy OpenShift Container Platform to an existing network, the isolation of cluster services is preserved by firewall rules that reference the machines in your cluster by the cluster's infrastructure ID. Only traffic within the cluster is allowed.

If you deploy multiple clusters to the same VPC, the following components might share access between clusters:

- The API, which is globally available with an external publishing strategy or available throughout the network in an internal publishing strategy
- Debugging tools, such as ports on VM instances that are open to the machine CIDR for SSH and ICMP access

8.9.4. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.11, you require access to the internet to install your cluster.

You must have internet access to:

- Access OpenShift Cluster Manager Hybrid Cloud Console to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access Quay.io to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.

IMPORTANT

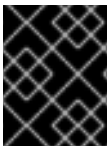
If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

8.9.5. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the **~/.ssh/authorized_keys** list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The **./openshift-install gather** command also requires the SSH public key to be in place on the cluster nodes.



IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.

NOTE

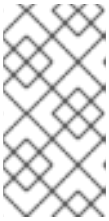
You must use a local key, not one that you configured with platform-specific approaches such as AWS key pairs.

Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N '' -f <path>/<file_name> 1
```

1 Specify the path and file name, such as ~/**.ssh/id_ed25519**, of the new SSH key. If you have an existing key pair, ensure your public key is in the your ~/**.ssh** directory.



NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS validated or Modules In Process cryptographic libraries on the **x86_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

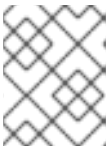
2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the ~/**.ssh/id_ed25519.pub** public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the **./openshift-install gather** command.



NOTE

On some distributions, default SSH private key identities such as ~/**.ssh/id_rsa** and ~/**.ssh/id_dsa** are managed automatically.

a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
-
```

```
$ eval "$(ssh-agent -s)"
```

Example output

```
Agent pid 31874
```

NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

1 Specify the path and file name for your SSH private key, such as **~/.ssh/id_ed25519**

Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

5. Set the **GOOGLE_APPLICATION_CREDENTIALS** environment variable to the full path to your service account private key file.

```
$ export GOOGLE_APPLICATION_CREDENTIALS="<your_service_account_file>"
```

6. Verify that the credentials were applied.

```
$ gcloud auth list
```

Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

8.9.6. Obtaining the installation program

Before you install OpenShift Container Platform, download the installation file on a local computer.

Prerequisites

- You have a computer that runs Linux or macOS, with 500 MB of local disk space.

Procedure

1. Access the Infrastructure Provider page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.

2. Select your infrastructure provider.

3. Navigate to the page for your installation type, download the installation program that corresponds with your host operating system and architecture, and place the file in the directory where you will store the installation configuration files.

IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.

IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation pull secret from the Red Hat OpenShift Cluster Manager . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

8.9.7. Manually creating the installation configuration file

For installations of a private OpenShift Container Platform cluster that are only accessible from an internal network and are not visible to the internet, you must manually generate your installation configuration file.

Prerequisites

- You have an SSH public key on your local machine to provide to the installation program. The key will be used for SSH authentication onto your cluster nodes for debugging and disaster recovery.
- You have obtained the OpenShift Container Platform installation program and the pull secret for your cluster.

Procedure

1. Create an installation directory to store your required installation assets in:

```
$ mkdir <installation_directory>
```

IMPORTANT

You must create a directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

2. Customize the sample **install-config.yaml** file template that is provided and save it in the **<installation_directory>**.

NOTE

You must name this configuration file **install-config.yaml**.

NOTE

For some platform types, you can alternatively run **./openshift-install create install-config --dir <installation_directory>** to generate an **install-config.yaml** file. You can provide details about your cluster configuration at the prompts.

3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.

IMPORTANT

The **install-config.yaml** file is consumed during the next step of the installation process. You must back it up now.

8.9.7.1. Installation configuration parameters

Before you deploy an OpenShift Container Platform cluster, you provide parameter values to describe your account on the cloud platform that hosts your cluster and optionally customize your cluster's platform. When you create the **install-config.yaml** installation configuration file, you provide values for the required parameters through the command line. If you customize your cluster, you can modify the **install-config.yaml** file to provide more details about the platform.

NOTE

After installation, you cannot modify these parameters in the **install-config.yaml** file.

8.9.7.1.1. Required configuration parameters

Required installation configuration parameters are described in the following table:

Table 8.32. Required parameters

Parameter	Description	Values

Parameter	Description	Values
apiVersion	The API version for the **install-config.yaml** content. The current version is **v1**. The installer may also support older API versions.	String
baseDomain	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the **baseDomain** and **metadata.name** parameter values that uses the **<metadata.name>.<baseDomain>** format.	A fully-qualified domain or subdomain name, such as **example.com**.
metadata	Kubernetes resource **ObjectMeta**, from which only the **name** parameter is consumed.	Object
metadata.name	The name of the cluster. DNS records for the cluster are all subdomains of **{{.metadata.name}}.{{.baseDomain}}**.	String of lowercase letters, hyphens (**-**), and periods (**.**), such as **dev**.
platform	The configuration for the specific platform upon which to perform the installation: **alibabacloud**, **aws**, **baremetal**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**. For additional information about **platform.<platform>** parameters, consult the table for your specific platform that follows.	Object

Parameter	Description	Values
pullSecret	Get a pull secret from the Red Hat OpenShift Cluster Manager to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	<pre>{ "auths":{ "cloud.openshift.com":{ "auth":"b3Blb=", "email":"you@example.com" }, "quay.io":{ "auth":"b3Blb=", "email":"you@example.com" } } }</pre>

8.9.7.1.2. Network configuration parameters

You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

Only IPv4 addresses are supported.

NOTE

Globalnet is not supported with Red Hat OpenShift Data Foundation disaster recovery solutions. For regional disaster recovery scenarios, ensure that you use a nonoverlapping range of private IP addresses for the cluster and service networks in each cluster.

Table 8.33. Network parameters

Parameter	Description	Values
networking	The configuration for the cluster network.	Object  **NOTE** You cannot modify parameters specified by the **networking** object after installation.

Parameter	Description	Values
networking.networkType	The cluster network provider Container Network Interface (CNI) cluster network provider to install.	Either **OpenShiftSDN** or **OVNKubernetes**. **OpenShiftSDN** is a CNI provider for all-Linux networks. **OVNKubernetes** is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is **OpenShiftSDN**.
networking.clusterNetwork	The IP address blocks for pods. The default value is **10.128.0.0/14** with a host prefix of **/23**. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: ``` networking: clusterNetwork: - cidr: 10.128.0.0/14 hostPrefix: 23 ```
networking.clusterNetwork.cidr	Required if you use **networking.clusterNetwork**. An IP address block. An IPv4 network.	An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between **0** and **32**.
networking.clusterNetwork.hostPrefix	The subnet prefix length to assign to each individual node. For example, if **hostPrefix** is set to **23** then each node is assigned a **/23** subnet out of the given **cidr**. A **hostPrefix** value of **23** provides 510 (2^(32 - 23) - 2) pod IP addresses.	A subnet prefix. The default value is **23**.
networking.serviceNetwork	The IP address block for services. The default value is **172.30.0.0/16**. The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.	An array with an IP address block in CIDR format. For example: ``` networking: serviceNetwork: - 172.30.0.0/16 ```
networking.machineNetwork	The IP address blocks for machines. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: ``` networking: machineNetwork: - cidr: 10.0.0.0/16 ```

Parameter	Description	Values
networking.machineNetwork.cidr	Required if you use **networking.machineNetwork**. An IP address block. The default value is **10.0.0.0/16** for all platforms other than libvirt. For libvirt, the default value is **192.168.126.0/24**.	An IP network block in CIDR notation. For example, **10.0.0.0/16**.  **NOTE** Set the **networking.machineNetwork** to match the CIDR that the preferred NIC resides in.

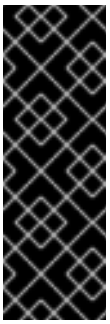
8.9.7.1.3. Optional configuration parameters

Optional installation configuration parameters are described in the following table:

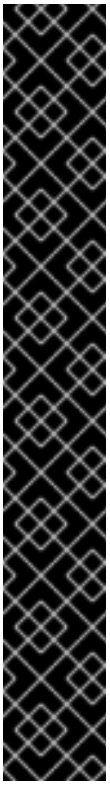
Table 8.34. Optional parameters

Parameter	Description	Values
additionalTrustBundle	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String
capabilities	Controls the installation of optional core cluster components. You can reduce the footprint of your OpenShift Container Platform cluster by disabling optional components.	String array
capabilities.baselineCapabilitySet	Selects an initial set of optional capabilities to enable. Valid values are **None**, **v4.11** and **vCurrent**. **v4.11** enables the **baremetal** Operator, the **marketplace** Operator, and the **openshift-samples** content. **vCurrent** installs the recommended set of capabilities for the current version of OpenShift Container Platform. The default value is **vCurrent**.	String

Parameter	Description	Values
capabilities.additionalEnabledCapabilities	Extends the set of optional capabilities beyond what you specify in **baselineCapabilitySet**. Valid values are **baremetal**, **marketplace** and **openshift-samples**. You may specify multiple capabilities in this parameter.	String array
cgroupsV2	Enables Linux control groups version 2 (cgroups v2) on specific nodes in your cluster. The OpenShift Container Platform process for enabling cgroups v2 disables all cgroup version 1 controllers and hierarchies. The OpenShift Container Platform cgroups version 2 feature is in Developer Preview and is not supported by Red Hat at this time.	**true**
compute	The configuration for the machines that comprise the compute nodes.	Array of **MachinePool** objects.
compute.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** (the default).	String
compute.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  IMPORTANT If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
compute.name	Required if you use **compute**. The name of the machine pool.	**worker**

Parameter	Description	Values
compute.platform	Required if you use **compute**. Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the **controlPlane.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
compute.replicas	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to **2**. The default value is **3**.
controlPlane	The configuration for the machines that comprise the control plane.	Array of **MachinePool** objects.
controlPlane.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** (the default).	String
controlPlane.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  IMPORTANT If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
controlPlane.name	Required if you use **controlPlane**. The name of the machine pool.	**master**

Parameter	Description	Values
controlPlane.platform	Required if you use **controlPlane**. Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the **compute.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
controlPlane.replicas	The number of control plane machines to provision.	The only supported value is **3**, which is the default value.
credentialsMode	The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported. If you are installing on GCP into a shared virtual private cloud (VPC), **credentialsMode** must be set to **Passthrough**.  **NOTE** Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the *Cloud Credential Operator* entry in the *Cluster Operators reference* content.  **NOTE** If your AWS account has service control policies (SCP) enabled, you must configure the **credentialsMode** parameter to **Mint**, **Passthrough** or **Manual**.	**Mint**, **Passthrough**, **Manual** or an empty string (**""**).
fips	Enable or disable FIPS mode. The default is **false** (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default	**false** or **true**

Parameter	Description	Values
	Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.  **IMPORTANT** To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.  **NOTE** If you are using Azure File storage, you cannot enable FIPS mode.	

Parameter	Description	Values
imageContentSources	Sources and repositories for the release-image content.	Array of objects. Includes a **source** and, optionally, **mirrors**, as described in the following rows of this table.
imageContentSources.source	Required if you use **imageContentSources**. Specify the repository that users refer to, for example, in image pull specifications.	String
imageContentSources.mirrors	Specify one or more repositories that may also contain the same images.	Array of strings
publish	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	**Internal** or **External**. To deploy a private cluster, which cannot be accessed from the internet, set **publish** to **Internal**. The default value is **External**.
sshKey	The SSH key to authenticate access to your cluster machines.  **NOTE** For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.	For example, **sshKey: ssh-ed25519 AAAA..**.

8.9.7.1.4. Additional Google Cloud Platform (GCP) configuration parameters

Additional GCP configuration parameters are described in the following table:

Table 8.35. Additional GCP parameters

Parameter	Description	Values
platform.gcp.network	The name of the existing VPC that you want to deploy your cluster to.	String.

Parameter	Description	Values
platform.gcp.projectID	The name of the GCP project where the installation program installs the cluster.	String.
platform.gcp.region	The name of the GCP region that hosts your cluster.	Any valid region name, such as **us-central1**.
platform.gcp.controlPlaneSubnet	The name of the existing subnet in your VPC that you want to deploy your control plane machines to.	The subnet name.
platform.gcp.computeSubnet	The name of the existing subnet in your VPC that you want to deploy your compute machines to.	The subnet name.
platform.gcp.licenses	A list of license URLs that must be applied to the compute images.  **IMPORTANT** The **licenses** parameter is a deprecated field and nested virtualization is enabled by default. It is not recommended to use this field.	Any license available with the license API, such as the license to enable nested virtualization. You cannot use this parameter with a mechanism that generates pre-built images. Using a license URL forces the installer to copy the source image before use.
platform.gcp.defaultMachinePlatform.osDisk.diskSizeGB	The size of the disk in gigabytes (GB).	Any size between 16 GB and 65536 GB.

Parameter	Description	Values
platform.gcp.defaultMachinePlatform.osDisk.diskType	The type of disk.	Either the default **pd-ssd** or the **pd-standard** disk type. The control plane nodes must be the **pd-ssd** disk type. The worker nodes can be either type.
platform.gcp.defaultMachinePlatform.osImage.project	Optional. By default, the installation program downloads and installs the RHCOS image that is used to boot control plane and compute machines. You can override the default behavior by specifying the location of a custom RHCOS image for the installation program to use for both types of machines.	String. The name of GCP project where the image is located.
platform.gcp.defaultMachinePlatform.osImage.name	The name of the custom RHCOS image for the installation program to use to boot control plane and compute machines. If you use **platform.gcp.defaultMachinePlatform.osImage.project**, this field is required.	String. The name of the RHCOS image.
platform.gcp.defaultMachinePlatform.type	The GCP machine type.	The GCP machine type.
platform.gcp.defaultMachinePlatform.zones	The availability zones where the installation program creates machines for the specified MachinePool.	A list of valid GCP availability zones, such as **us-central1-a**, in a YAML sequence.

Parameter	Description	Values
controlPlane.platform.gcp.osDisk.encryptionKey.kmsKey.name	The name of the customer managed encryption key to be used for control plane machine disk encryption.	The encryption key name.
controlPlane.platform.gcp.osDisk.encryptionKey.kmsKey.keyRing	For control plane machines, the name of the KMS key ring to which the KMS key belongs.	The KMS key ring name.
controlPlane.platform.gcp.osDisk.encryptionKey.kmsKey.location	For control plane machines, the GCP location in which the key ring exists. For more information on KMS locations, see Google's documentation on Cloud KMS locations.	The GCP location for the key ring.
controlPlane.platform.gcp.osDisk.encryptionKey.kmsKey.projectID	For control plane machines, the ID of the project in which the KMS key ring exists. This value defaults to the VM project ID if not set.	The GCP project ID.

Parameter	Description	Values
controlPlane.platform.gcp.osImage.project	Optional. By default, the installation program downloads and installs the Red Hat Enterprise Linux CoreOS (RHCOS) image that is used to boot control plane machines. You can override the default behavior by specifying the location of a custom RHCOS image for the installation program to use for control plane machines only.	String. The name of GCP project where the image is located.
controlPlane.platform.gcp.osImage.name	The name of the custom RHCOS image for the installation program to use to boot control plane machines. If you use **controlPlane.platform.gcp.osImage.project**, this field is required.	String. The name of the RHCOS image.
compute.platform.gcp.osDisk.encryptionKey.kmsKey.name	The name of the customer managed encryption key to be used for compute machine disk encryption.	The encryption key name.
compute.platform.gcp.osDisk.encryptionKey.kmsKey.keyRing	For compute machines, the name of the KMS key ring to which the KMS key belongs.	The KMS key ring name.

Parameter	Description	Values
compute.platform.gcp.osDisk.encryptionKey.kmsKey.location	For compute machines, the GCP location in which the key ring exists. For more information on KMS locations, see Google's documentation on Cloud KMS locations.	The GCP location for the key ring.
compute.platform.gcp.osDisk.encryptionKey.kmsKey.projectID	For compute machines, the ID of the project in which the KMS key ring exists. This value defaults to the VM project ID if not set.	The GCP project ID.
compute.platform.gcp.osImage.project	Optional. By default, the installation program downloads and installs the RHCOS image that is used to boot compute machines. You can override the default behavior by specifying the location of a custom RHCOS image for the installation program to use for compute machines only.	String. The name of GCP project where the image is located.
compute.platform.gcp.osImage.name	The name of the custom RHCOS image for the installation program to use to boot compute machines. If you use **compute.platform.gcp.osImage.project**, this field is required.	String. The name of the RHCOS image.

8.9.7.2. Minimum resource requirements for cluster installation

Each cluster machine must meet the following minimum requirements:

Table 8.36. Minimum resource requirements

Machine	Operating System	vCPU [1]	Virtual RAM	Storage	IOPS [2]
Bootstrap	RHCOS	4	16 GB	100 GB	300
Control plane	RHCOS	4	16 GB	100 GB	300
Compute	RHCOS, RHEL 8.6 and later [3]	2	8 GB	100 GB	300

1. One vCPU is equivalent to one physical core when simultaneous multithreading (SMT), or hyperthreading, is not enabled. When enabled, use the following formula to calculate the corresponding ratio: (threads per core × cores) × sockets = vCPUs.

2. OpenShift Container Platform and Kubernetes are sensitive to disk performance, and faster storage is recommended, particularly for etcd on the control plane nodes which require a 10 ms p99 fsync duration. Note that on many cloud platforms, storage size and IOPS scale together, so you might need to over-allocate storage volume to obtain sufficient performance.

3. As with all user-provisioned installations, if you choose to use RHEL compute machines in your cluster, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks. Use of RHEL 7 compute machines is deprecated and has been removed in OpenShift Container Platform 4.10 and later.

If an instance type for your platform meets the minimum requirements for cluster machines, it is supported to use in OpenShift Container Platform.

Additional resources

- Optimizing storage

8.9.7.3. Tested instance types for GCP

The following Google Cloud Platform instance types have been tested with OpenShift Container Platform.

> **Example 8.25. Machine series**
>
> - **C2**
> - **C2D**
> - **C3**
> - **E2**
> - **M1**
> - **N1**
> - **N2**

- **N2D**
- **Tau T2D**

8.9.7.4. Using custom machine types

Using a custom machine type to install a OpenShift Container Platform cluster is supported.

Consider the following when using a custom machine type:

- Similar to predefined instance types, custom machine types must meet the minimum resource requirements for control plane and compute machines. For more information, see "Minimum resource requirements for cluster installation".
- The name of the custom machine type must adhere to the following syntax: **custom-<number_of_cpus>-<amount_of_memory_in_mb>**

  For example, **custom-6-20480**.

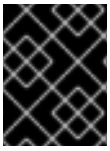
As part of the installation process, you specify the custom machine type in the **install-config.yaml** file.

Sample install-config.yaml file with a custom machine type

```
compute:
- architecture: amd64
  hyperthreading: Enabled
  name: worker
  platform:
    gcp:
      type: custom-6-20480
  replicas: 2
controlPlane:
  architecture: amd64
  hyperthreading: Enabled
  name: master
  platform:
    gcp:
      type: custom-6-20480
  replicas: 3
```

8.9.7.5. Sample customized install-config.yaml file for GCP

You can customize the **install-config.yaml** file to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.



IMPORTANT

This sample YAML file is provided for reference only. You must obtain your **install-config.yaml** file by using the installation program and modify it.

```
apiVersion: v1
baseDomain: example.com (1)
controlPlane: (2) (3)
```

```
  hyperthreading: Enabled 4
  name: master
  platform:
    gcp:
      type: n2-standard-4
      zones:
      - us-central1-a
      - us-central1-c
      osDisk:
        diskType: pd-ssd
        diskSizeGB: 1024
        encryptionKey: 5
          kmsKey:
            name: worker-key
            keyRing: test-machine-keys
            location: global
            projectID: project-id
        osImage: 6
          project: example-project-name
          name: example-image-name
  replicas: 3
compute: 7 8
- hyperthreading: Enabled 9
  name: worker
  platform:
    gcp:
      type: n2-standard-4
      zones:
      - us-central1-a
      - us-central1-c
      osDisk:
        diskType: pd-standard
        diskSizeGB: 128
        encryptionKey: 10
          kmsKey:
            name: worker-key
            keyRing: test-machine-keys
            location: global
            projectID: project-id
        osImage: 11
          project: example-project-name
          name: example-image-name
  replicas: 3
metadata:
  name: test-cluster 12
networking:
  clusterNetwork:
  - cidr: 10.128.0.0/14
    hostPrefix: 23
  machineNetwork:
  - cidr: 10.0.0.0/16
  networkType: OpenShiftSDN
  serviceNetwork:
  - 172.30.0.0/16
platform:
```

```
  gcp:
    projectID: openshift-production 13
    region: us-central1 14
    defaultMachinePlatform:
      osImage: 15
        project: example-project-name
        name: example-image-name
    network: existing_vpc 16
    controlPlaneSubnet: control_plane_subnet 17
    computeSubnet: compute_subnet 18
pullSecret: '{"auths": ...}' 19
fips: false 20
sshKey: ssh-ed25519 AAAA... 21
publish: Internal 22
```

1 12 13 14 19 Required. The installation program prompts you for this value.

2 7 If you do not provide these parameters and values, the installation program provides the default value.

3 8 The **controlPlane** section is a single mapping, but the **compute** section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, **-**, and the first line of the **controlPlane** section must not. Only one control plane pool is used.

4 9 Whether to enable or disable simultaneous multithreading, or **hyperthreading**. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores. You can disable it by setting the parameter value to **Disabled**. If you disable simultaneous multithreading in some cluster machines, you must disable it in all cluster machines.

IMPORTANT

If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance. Use larger machine types, such as **n1-standard-8**, for your machines if you disable simultaneous multithreading.

5 10 Optional: The custom encryption key section to encrypt both virtual machines and persistent volumes. Your default compute service account must have the permissions granted to use your KMS key and have the correct IAM role assigned. The default service account name follows the **service-<project_number>@compute-system.iam.gserviceaccount.com** pattern. For more information on granting the correct permissions for your service account, see "Machine management" → "Creating machine sets" → "Creating a machine set on GCP".

6 11 15 Optional: A custom Red Hat Enterprise Linux CoreOS (RHCOS) image for the installation program to use to boot control plane and compute machines. The **project** and **name** parameters under **platform.gcp.defaultMachinePlatform.osImage** apply to both control plane and compute machines. If the **project** and **name** parameters under **controlPlane.platform.gcp.osImage** or **compute.platform.gcp.osImage** are set, they override the **platform.gcp.defaultMachinePlatform.osImage** parameters.

16 Specify the name of an existing VPC.

17 Specify the name of the existing subnet to deploy the control plane machines to. The subnet must

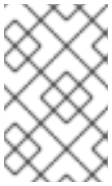
18 Specify the name of the existing subnet to deploy the compute machines to. The subnet must belong to the VPC that you specified.

20 Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.

IMPORTANT

To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.

21 You can optionally provide the **sshKey** value that you use to access the machines in your cluster.



NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

22 How to publish the user-facing endpoints of your cluster. Set **publish** to **Internal** to deploy a private cluster, which cannot be accessed from the internet. The default value is **External**.

8.9.7.6. Create an Ingress Controller with global access on GCP

You can create an Ingress Controller that has global access to a Google Cloud Platform (GCP) cluster. Global access is only available to Ingress Controllers using internal load balancers.

Prerequisites

- You created the **install-config.yaml** and complete any modifications to it.

Procedure

Create an Ingress Controller with global access on a new GCP cluster.

1. Change to the directory that contains the installation program and create a manifest file:

```
$ ./openshift-install create manifests --dir <installation_directory> 1
```

1 For **<installation_directory>**, specify the name of the directory that contains the **install-config.yaml** file for your cluster.

2. Create a file that is named **cluster-ingress-default-ingresscontroller.yaml** in the **<installation_directory>/manifests/** directory:

```
$ touch <installation_directory>/manifests/cluster-ingress-default-ingresscontroller.yaml 1
```

1 For **<installation_directory>**, specify the directory name that contains the **manifests/** directory for your cluster.

After creating the file, several network configuration files are in the **manifests/** directory, as shown:

```
$ ls <installation_directory>/manifests/cluster-ingress-default-ingresscontroller.yaml
```

Example output

```
cluster-ingress-default-ingresscontroller.yaml
```

3. Open the **cluster-ingress-default-ingresscontroller.yaml** file in an editor and enter a custom resource (CR) that describes the Operator configuration you want:

Sample clientAccess configuration to Global

```
apiVersion: operator.openshift.io/v1
kind: IngressController
metadata:
  name: default
  namespace: openshift-ingress-operator
spec:
  endpointPublishingStrategy:
    loadBalancer:
      providerParameters:
        gcp:
          clientAccess: Global 1
        type: GCP
      scope: Internal 2
    type: LoadBalancerService
```

1 Set **gcp.clientAccess** to **Global**.

2 Global access is only available to Ingress Controllers using internal load balancers.

8.9.8. Additional resources

- Enabling customer-managed encryption keys for a machine set

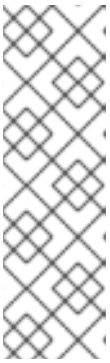
8.9.8.1. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to

hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.



NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
```

1. A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
2. A proxy URL to use for creating HTTPS connections outside the cluster.
3. A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use ***** to bypass the proxy for all destinations.
4. If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace that contains one or more additional CA certificates that are required for proxying HTTPS connections. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges these contents with the Red Hat Enterprise Linux CoreOS (RHCOS) trust bundle, and this config map is referenced in the **trustedCA** field of the **Proxy** object. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.

NOTE

The installation program does not support the proxy **readinessEndpoints** field.

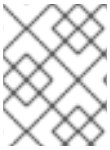
NOTE

If the installer times out, restart and then complete the deployment by using the **wait-for** command of the installer. For example:

```
$ ./openshift-install wait-for install-complete --log-level debug
```

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.



NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

8.9.9. Deploying the cluster

You can install OpenShift Container Platform on a compatible cloud platform.

IMPORTANT

You can run the **create cluster** command of the installation program only once, during initial installation.

Prerequisites

- Configure an account with the cloud platform that hosts your cluster.
- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.

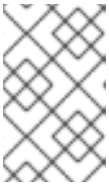
Procedure

1. Remove any existing GCP credentials that do not use the service account key for the GCP account that you configured for your cluster and that are stored in the following locations:
   - The **GOOGLE_CREDENTIALS**, **GOOGLE_CLOUD_KEYFILE_JSON**, or **GCLOUD_KEYFILE_JSON** environment variables
   - The ~/**.gcp/osServiceAccount.json** file
   - The **gcloud cli** default credentials
2. Change to the directory that contains the installation program and initialize the cluster deployment:

```
$ ./openshift-install create cluster --dir <installation_directory> \ 1
    --log-level=info 2
```

1 For **<installation_directory>**, specify the location of your customized **./install-config.yaml** file.

2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.



NOTE

If the cloud provider account that you configured on your host does not have sufficient permissions to deploy the cluster, the installation process stops, and the missing permissions are displayed.

3. Optional: You can reduce the number of permissions for the service account that you used to install the cluster.
   - If you assigned the **Owner** role to your service account, you can remove that role and replace it with the **Viewer** role.
   - If you included the **Service Account Key Admin** role, you can remove it.

Verification

When the cluster deployment completes successfully:

- The terminal displays directions for accessing your cluster, including a link to the web console and credentials for the **kubeadmin** user.
- Credential information also outputs to **<installation_directory>/.openshift_install.log**.

IMPORTANT

Do not delete the installation program or the files that the installation program creates. Both are required to delete the cluster.

Example output

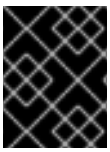
```
...
INFO Install complete!
INFO To access the cluster as the system:admin user when using 'oc', run 'export
KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
INFO Access the OpenShift web-console here: https://console-openshift-
console.apps.mycluster.example.com
INFO Login to the console with user: "kubeadmin", and password: "password"
INFO Time elapsed: 36m22s
```

IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

8.9.10. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.



IMPORTANT

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.11. Download and install the new version of **oc**.

Installing the OpenShift CLI on Linux
You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the architecture in the **Product Variant** drop-down menu.
3. Select the appropriate version in the **Version** drop-down menu.
4. Click **Download Now** next to the **OpenShift v4.11 Linux Client** entry and save the file.
5. Unpack the archive:

```
$ tar xvf <file>
```

6. Place the **oc** binary in a directory that is on your **PATH**.
   To check your **PATH**, execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

–

Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.
   To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
C:\> oc <command>
```

Installing the OpenShift CLI on macOS

You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 macOS Client** entry and save the file.

NOTE

For macOS arm64, choose the **OpenShift v4.11 macOS arm64 Client** entry.

4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your PATH.
   To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

8.9.11. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

Example output

```
system:admin
```

Additional resources

- See Accessing the web console for more details about accessing and understanding the OpenShift Container Platform web console.

8.9.12. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.11, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to OpenShift Cluster Manager Hybrid Cloud Console.

After you confirm that your OpenShift Cluster Manager Hybrid Cloud Console inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, use subscription watch to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

Additional resources

- See About remote health monitoring for more information about the Telemetry service

8.9.13. Next steps

- Customize your cluster.
- If necessary, you can opt out of remote health reporting .

8.10. INSTALLING A CLUSTER ON USER-PROVISIONED INFRASTRUCTURE IN GCP BY USING DEPLOYMENT MANAGER TEMPLATES

In OpenShift Container Platform version 4.11, you can install a cluster on Google Cloud Platform (GCP) that uses infrastructure that you provide.

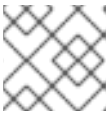
The steps for performing a user-provided infrastructure install are outlined here. Several Deployment Manager templates are provided to assist in completing these steps or to help model your own. You are also free to create the required resources through other methods.

IMPORTANT

The steps for performing a user-provisioned infrastructure installation are provided as an example only. Installing a cluster with infrastructure you provide requires knowledge of the cloud provider and the installation process of OpenShift Container Platform. Several Deployment Manager templates are provided to assist in completing these steps or to help model your own. You are also free to create the required resources through other methods; the templates are just an example.

8.10.1. Prerequisites

- You reviewed details about the OpenShift Container Platform installation and update processes.
- You read the documentation on selecting a cluster installation method and preparing it for users.
- If you use a firewall and plan to use the Telemetry service, you configured the firewall to allow the sites that your cluster requires access to.
- If the cloud identity and access management (IAM) APIs are not accessible in your environment, or if you do not want to store an administrator-level credential secret in the **kube-system** namespace, you can manually create and maintain IAM credentials .



NOTE

Be sure to also review this site list if you are configuring a proxy.

8.10.2. Certificate signing requests management

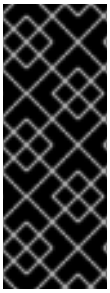
Because your cluster has limited access to automatic machine management when you use infrastructure that you provision, you must provide a mechanism for approving cluster certificate signing requests (CSRs) after installation. The **kube-controller-manager** only approves the kubelet client CSRs. The **machine-approver** cannot guarantee the validity of a serving certificate that is requested by using kubelet credentials because it cannot confirm that the correct machine issued the request. You must determine and implement a method of verifying the validity of the kubelet serving certificate requests and approving them.

8.10.3. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.11, you require access to the internet to install your cluster.

You must have internet access to:

- Access OpenShift Cluster Manager Hybrid Cloud Console to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access Quay.io to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.



IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

8.10.4. Configuring your GCP project

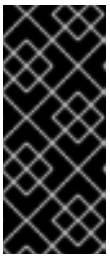
Before you can install OpenShift Container Platform, you must configure a Google Cloud Platform (GCP) project to host it.

8.10.4.1. Creating a GCP project

To install OpenShift Container Platform, you must create a project in your Google Cloud Platform (GCP) account to host the cluster.

Procedure

- Create a project to host your OpenShift Container Platform cluster. See Creating and Managing Projects in the GCP documentation.



IMPORTANT

Your GCP project must use the Premium Network Service Tier if you are using installer-provisioned infrastructure. The Standard Network Service Tier is not supported for clusters installed using the installation program. The installation program configures internal load balancing for the **api-int.<cluster_name>.<base_domain>** URL; the Premium Tier is required for internal load balancing.

8.10.4.2. Enabling API services in GCP

Your Google Cloud Platform (GCP) project requires access to several API services to complete OpenShift Container Platform installation.

Prerequisites

- You created a project to host your cluster.

Procedure

- Enable the following required API services in the project that hosts your cluster. You may also enable optional API services which are not required for installation. See Enabling services in the GCP documentation.

Table 8.37. Required API services

API service	Console service name
Compute Engine API	**compute.googleapis.com**
Cloud Resource Manager API	**cloudresourcemanager.googleapis.com**
Google DNS API	**dns.googleapis.com**
IAM Service Account Credentials API	**iamcredentials.googleapis.com**
Identity and Access Management (IAM) API	**iam.googleapis.com**
Service Usage API	**serviceusage.googleapis.com**

Table 8.38. Optional API services

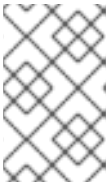
API service	Console service name
Cloud Deployment Manager V2 API	**deploymentmanager.googleapis.com**
Google Cloud APIs	**cloudapis.googleapis.com**
Service Management API	**servicemanagement.googleapis.com**
Google Cloud Storage JSON API	**storage-api.googleapis.com**
Cloud Storage	**storage-component.googleapis.com**

8.10.4.3. Configuring DNS for GCP

To install OpenShift Container Platform, the Google Cloud Platform (GCP) account you use must have a dedicated public hosted zone in the same project that you host the OpenShift Container Platform cluster. This zone must be authoritative for the domain. The DNS service provides cluster DNS resolution and name lookup for external connections to the cluster.

Procedure

1. Identify your domain, or subdomain, and registrar. You can transfer an existing domain and registrar or obtain a new one through GCP or another source.



NOTE

If you purchase a new domain, it can take time for the relevant DNS changes to propagate. For more information about purchasing domains through Google, see Google Domains.

2. Create a public hosted zone for your domain or subdomain in your GCP project. See Creating public zones in the GCP documentation.
   Use an appropriate root domain, such as **openshiftcorp.com**, or subdomain, such as **clusters.openshiftcorp.com**.

3. Extract the new authoritative name servers from the hosted zone records. See Look up your Cloud DNS name servers in the GCP documentation.
   You typically have four name servers.

4. Update the registrar records for the name servers that your domain uses. For example, if you registered your domain to Google Domains, see the following topic in the Google Domains Help: How to switch to custom name servers .

5. If you migrated your root domain to Google Cloud DNS, migrate your DNS records. See Migrating to Cloud DNS in the GCP documentation.

6. If you use a subdomain, follow your company's procedures to add its delegation records to the parent domain. This process might include a request to your company's IT department or the division that controls the root domain and DNS services for your company.

8.10.4.4. GCP account limits

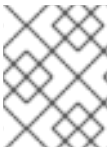
The OpenShift Container Platform cluster uses a number of Google Cloud Platform (GCP) components, but the default Quotas do not affect your ability to install a default OpenShift Container Platform cluster.

A default cluster, which contains three compute and three control plane machines, uses the following resources. Note that some resources are required only during the bootstrap process and are removed after the cluster deploys.

Table 8.39. GCP resources used in a default cluster

Service	Component	Location	Total resources required	Resources removed after bootstrap
Service account	IAM	Global	5	0
Firewall rules	Networking	Global	11	1
Forwarding rules	Compute	Global	2	0
Health checks	Compute	Global	2	0
Images	Compute	Global	1	0
Networks	Networking	Global	1	0

Service	Component	Location	Total resources required	Resources removed after bootstrap
Routers	Networking	Global	1	0
Routes	Networking	Global	2	0
Subnetworks	Compute	Global	2	0
Target pools	Networking	Global	2	0



NOTE

If any of the quotas are insufficient during installation, the installation program displays an error that states both which quota was exceeded and the region.

Be sure to consider your actual cluster size, planned cluster growth, and any usage from other clusters that are associated with your account. The CPU, static IP addresses, and persistent disk SSD (storage) quotas are the ones that are most likely to be insufficient.

If you plan to deploy your cluster in one of the following regions, you will exceed the maximum storage quota and are likely to exceed the CPU quota limit:

- **asia-east2**
- **asia-northeast2**
- **asia-south1**
- **australia-southeast1**
- **europe-north1**
- **europe-west2**
- **europe-west3**
- **europe-west6**
- **northamerica-northeast1**
- **southamerica-east1**
- **us-west2**

You can increase resource quotas from the GCP console, but you might need to file a support ticket. Be sure to plan your cluster size early so that you can allow time to resolve the support ticket before you install your OpenShift Container Platform cluster.

8.10.4.5. Creating a service account in GCP

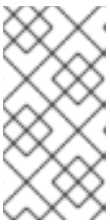
OpenShift Container Platform requires a Google Cloud Platform (GCP) service account that provides authentication and authorization to access data in the Google APIs. If you do not have an existing IAM service account that contains the required roles in your project, you must create one.

Prerequisites

- You created a project to host your cluster.

Procedure

1. Create a service account in the project that you use to host your OpenShift Container Platform cluster. See Creating a service account in the GCP documentation.
2. Grant the service account the appropriate permissions. You can either grant the individual permissions that follow or assign the **Owner** role to it. See Granting roles to a service account for specific resources.



NOTE

While making the service account an owner of the project is the easiest way to gain the required permissions, it means that service account has complete control over the project. You must determine if the risk that comes from offering that power is acceptable.

3. Create the service account key in JSON format. See Creating service account keys in the GCP documentation.
   The service account key is required to create a cluster.

8.10.4.6. Required GCP roles

When you attach the **Owner** role to the service account that you create, you grant that service account all permissions, including those that are required to install OpenShift Container Platform. If your organization's security policies require a more restrictive set of permissions, you can create a service account with the following permissions. If you deploy your cluster into an existing virtual private cloud (VPC), the service account does not require certain networking permissions, which are noted in the following lists:

Required roles for the installation program

- Compute Admin
- Security Admin
- Service Account Admin
- Service Account Key Admin
- Service Account User
- Storage Admin

Required roles for creating network resources during installation

- DNS Administrator

Required roles for user-provisioned GCP infrastructure

- Deployment Manager Editor

The roles are applied to the service accounts that the control plane and compute machines use:

Table 8.40. GCP service account permissions

Account	Roles
Control Plane	**roles/compute.instanceAdmin**
	roles/compute.networkAdmin
	roles/compute.securityAdmin
	roles/storage.admin
	roles/iam.serviceAccountUser
Compute	**roles/compute.viewer**
	roles/storage.admin

8.10.4.7. Required GCP permissions for user-provisioned infrastructure

When you attach the **Owner** role to the service account that you create, you grant that service account all permissions, including those that are required to install OpenShift Container Platform.

If your organization's security policies require a more restrictive set of permissions, you can create custom roles with the necessary permissions. The following permissions are required for the user-provisioned infrastructure for creating and deleting the OpenShift Container Platform cluster.

Example 8.26. Required permissions for creating network resources

- **compute.addresses.create**
- **compute.addresses.createInternal**
- **compute.addresses.delete**
- **compute.addresses.get**
- **compute.addresses.list**
- **compute.addresses.use**
- **compute.addresses.useInternal**
- **compute.firewalls.create**
- **compute.firewalls.delete**

- **compute.firewalls.get**
- **compute.firewalls.list**
- **compute.forwardingRules.create**
- **compute.forwardingRules.get**
- **compute.forwardingRules.list**
- **compute.forwardingRules.setLabels**
- **compute.networks.create**
- **compute.networks.get**
- **compute.networks.list**
- **compute.networks.updatePolicy**
- **compute.routers.create**
- **compute.routers.get**
- **compute.routers.list**
- **compute.routers.update**
- **compute.routes.list**
- **compute.subnetworks.create**
- **compute.subnetworks.get**
- **compute.subnetworks.list**
- **compute.subnetworks.use**
- **compute.subnetworks.useExternalIp**

Example 8.27. Required permissions for creating load balancer resources

- **compute.regionBackendServices.create**
- **compute.regionBackendServices.get**
- **compute.regionBackendServices.list**
- **compute.regionBackendServices.update**
- **compute.regionBackendServices.use**
- **compute.targetPools.addInstance**
- **compute.targetPools.create**
- **compute.targetPools.get**

- **compute.targetPools.list**
- **compute.targetPools.removeInstance**
- **compute.targetPools.use**

Example 8.28. Required permissions for creating DNS resources

- **dns.changes.create**
- **dns.changes.get**
- **dns.managedZones.create**
- **dns.managedZones.get**
- **dns.managedZones.list**
- **dns.networks.bindPrivateDNSZone**
- **dns.resourceRecordSets.create**
- **dns.resourceRecordSets.list**
- **dns.resourceRecordSets.update**

Example 8.29. Required permissions for creating Service Account resources

- **iam.serviceAccountKeys.create**
- **iam.serviceAccountKeys.delete**
- **iam.serviceAccountKeys.get**
- **iam.serviceAccountKeys.list**
- **iam.serviceAccounts.actAs**
- **iam.serviceAccounts.create**
- **iam.serviceAccounts.delete**
- **iam.serviceAccounts.get**
- **iam.serviceAccounts.list**
- **resourcemanager.projects.get**
- **resourcemanager.projects.getIamPolicy**
- **resourcemanager.projects.setIamPolicy**

Example 8.30. Required permissions for creating compute resources

- **compute.disks.create**
- **compute.disks.get**
- **compute.disks.list**
- **compute.instanceGroups.create**
- **compute.instanceGroups.delete**
- **compute.instanceGroups.get**
- **compute.instanceGroups.list**
- **compute.instanceGroups.update**
- **compute.instanceGroups.use**
- **compute.instances.create**
- **compute.instances.delete**
- **compute.instances.get**
- **compute.instances.list**
- **compute.instances.setLabels**
- **compute.instances.setMetadata**
- **compute.instances.setServiceAccount**
- **compute.instances.setTags**
- **compute.instances.use**
- **compute.machineTypes.get**
- **compute.machineTypes.list**

Example 8.31. Required for creating storage resources

- **storage.buckets.create**
- **storage.buckets.delete**
- **storage.buckets.get**
- **storage.buckets.list**
- **storage.objects.create**
- **storage.objects.delete**
- **storage.objects.get**
- **storage.objects.list**

Example 8.32. Required permissions for creating health check resources

- **compute.healthChecks.create**
- **compute.healthChecks.get**
- **compute.healthChecks.list**
- **compute.healthChecks.useReadOnly**
- **compute.httpHealthChecks.create**
- **compute.httpHealthChecks.get**
- **compute.httpHealthChecks.list**
- **compute.httpHealthChecks.useReadOnly**

Example 8.33. Required permissions to get GCP zone and region related information

- **compute.globalOperations.get**
- **compute.regionOperations.get**
- **compute.regions.list**
- **compute.zoneOperations.get**
- **compute.zones.get**
- **compute.zones.list**

Example 8.34. Required permissions for checking services and quotas

- **monitoring.timeSeries.list**
- **serviceusage.quotas.get**
- **serviceusage.services.list**

Example 8.35. Required IAM permissions for installation

- **iam.roles.get**

Example 8.36. Required Images permissions for installation

- **compute.images.create**
- **compute.images.delete**

- **compute.images.get**
- **compute.images.list**

Example 8.37. Optional permission for running gather bootstrap

- **compute.instances.getSerialPortOutput**

Example 8.38. Required permissions for deleting network resources

- **compute.addresses.delete**
- **compute.addresses.deleteInternal**
- **compute.addresses.list**
- **compute.firewalls.delete**
- **compute.firewalls.list**
- **compute.forwardingRules.delete**
- **compute.forwardingRules.list**
- **compute.networks.delete**
- **compute.networks.list**
- **compute.networks.updatePolicy**
- **compute.routers.delete**
- **compute.routers.list**
- **compute.routes.list**
- **compute.subnetworks.delete**
- **compute.subnetworks.list**

Example 8.39. Required permissions for deleting load balancer resources

- **compute.regionBackendServices.delete**
- **compute.regionBackendServices.list**
- **compute.targetPools.delete**
- **compute.targetPools.list**

Example 8.40. Required permissions for deleting DNS resources

- **dns.changes.create**
- **dns.managedZones.delete**
- **dns.managedZones.get**
- **dns.managedZones.list**
- **dns.resourceRecordSets.delete**
- **dns.resourceRecordSets.list**

Example 8.41. Required permissions for deleting Service Account resources

- **iam.serviceAccounts.delete**
- **iam.serviceAccounts.get**
- **iam.serviceAccounts.list**
- **resourcemanager.projects.getIamPolicy**
- **resourcemanager.projects.setIamPolicy**

Example 8.42. Required permissions for deleting compute resources

- **compute.disks.delete**
- **compute.disks.list**
- **compute.instanceGroups.delete**
- **compute.instanceGroups.list**
- **compute.instances.delete**
- **compute.instances.list**
- **compute.instances.stop**
- **compute.machineTypes.list**

Example 8.43. Required for deleting storage resources

- **storage.buckets.delete**
- **storage.buckets.getIamPolicy**
- **storage.buckets.list**
- **storage.objects.delete**
- **storage.objects.list**

Example 8.44. Required permissions for deleting health check resources

- **compute.healthChecks.delete**
- **compute.healthChecks.list**
- **compute.httpHealthChecks.delete**
- **compute.httpHealthChecks.list**

Example 8.45. Required Images permissions for deletion

- **compute.images.delete**
- **compute.images.list**

Example 8.46. Required permissions to get Region related information

- **compute.regions.get**

Example 8.47. Required Deployment Manager permissions

- **deploymentmanager.deployments.create**
- **deploymentmanager.deployments.delete**
- **deploymentmanager.deployments.get**
- **deploymentmanager.deployments.list**
- **deploymentmanager.manifests.get**
- **deploymentmanager.operations.get**
- **deploymentmanager.resources.list**

Additional resources

- Optimizing storage

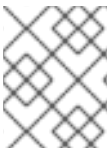
8.10.4.8. Supported GCP regions

You can deploy an OpenShift Container Platform cluster to the following Google Cloud Platform (GCP) regions:

- **asia-east1** (Changhua County, Taiwan)
- **asia-east2** (Hong Kong)
- **asia-northeast1** (Tokyo, Japan)

- **asia-northeast2** (Osaka, Japan)
- **asia-northeast3** (Seoul, South Korea)
- **asia-south1** (Mumbai, India)
- **asia-south2** (Delhi, India)
- **asia-southeast1** (Jurong West, Singapore)
- **asia-southeast2** (Jakarta, Indonesia)
- **australia-southeast1** (Sydney, Australia)
- **australia-southeast2** (Melbourne, Australia)
- **europe-central2** (Warsaw, Poland)
- **europe-north1** (Hamina, Finland)
- **europe-southwest1** (Madrid, Spain)
- **europe-west1** (St. Ghislain, Belgium)
- **europe-west2** (London, England, UK)
- **europe-west3** (Frankfurt, Germany)
- **europe-west4** (Eemshaven, Netherlands)
- **europe-west6** (Zürich, Switzerland)
- **europe-west8** (Milan, Italy)
- **europe-west9** (Paris, France)
- **europe-west12** (Turin, Italy)
- **northamerica-northeast1** (Montréal, Québec, Canada)
- **northamerica-northeast2** (Toronto, Ontario, Canada)
- **southamerica-east1** (São Paulo, Brazil)
- **southamerica-west1** (Santiago, Chile)
- **us-central1** (Council Bluffs, Iowa, USA)
- **us-east1** (Moncks Corner, South Carolina, USA)
- **us-east4** (Ashburn, Northern Virginia, USA)
- **us-east5** (Columbus, Ohio)
- **us-south1** (Dallas, Texas)
- **us-west1** (The Dalles, Oregon, USA)

- **us-west2** (Los Angeles, California, USA)
- **us-west3** (Salt Lake City, Utah, USA)
- **us-west4** (Las Vegas, Nevada, USA)



NOTE

To determine which machine type instances are available by region and zone, see the Google documentation.

8.10.4.9. Installing and configuring CLI tools for GCP

To install OpenShift Container Platform on Google Cloud Platform (GCP) using user-provisioned infrastructure, you must install and configure the CLI tools for GCP.

Prerequisites

- You created a project to host your cluster.
- You created a service account and granted it the required permissions.

Procedure

1. Install the following binaries in **$PATH**:
   - **gcloud**
   - **gsutil**

   See Install the latest Cloud SDK version in the GCP documentation.
2. Authenticate using the **gcloud** tool with your configured service account.
   See Authorizing with a service account in the GCP documentation.

8.10.5. Requirements for a cluster with user-provisioned infrastructure

For a cluster that contains user-provisioned infrastructure, you must deploy all of the required machines.

This section describes the requirements for deploying OpenShift Container Platform on user-provisioned infrastructure.

8.10.5.1. Required machines for cluster installation

The smallest OpenShift Container Platform clusters require the following hosts:

Table 8.41. Minimum required hosts

Hosts	Description
One temporary bootstrap machine	The cluster requires the bootstrap machine to deploy the OpenShift Container Platform cluster on the three control plane machines. You can remove the bootstrap machine after you install the cluster.

Hosts	Description
Three control plane machines	The control plane machines run the Kubernetes and OpenShift Container Platform services that form the control plane.
At least two compute machines, which are also known as worker machines.	The workloads requested by OpenShift Container Platform users run on the compute machines.

IMPORTANT

To maintain high availability of your cluster, use separate physical hosts for these cluster machines.

The bootstrap and control plane machines must use Red Hat Enterprise Linux CoreOS (RHCOS) as the operating system. However, the compute machines can choose between Red Hat Enterprise Linux CoreOS (RHCOS), Red Hat Enterprise Linux (RHEL) 8.6 and later.

Note that RHCOS is based on Red Hat Enterprise Linux (RHEL) 8 and inherits all of its hardware certifications and requirements. See Red Hat Enterprise Linux technology capabilities and limits .

8.10.5.2. Minimum resource requirements for cluster installation

Each cluster machine must meet the following minimum requirements:

Table 8.42. Minimum resource requirements

Machine	Operating System	vCPU [1]	Virtual RAM	Storage	IOPS [2]
Bootstrap	RHCOS	4	16 GB	100 GB	300
Control plane	RHCOS	4	16 GB	100 GB	300
Compute	RHCOS, RHEL 8.6 and later [3]	2	8 GB	100 GB	300

1. One vCPU is equivalent to one physical core when simultaneous multithreading (SMT), or hyperthreading, is not enabled. When enabled, use the following formula to calculate the corresponding ratio: (threads per core × cores) × sockets = vCPUs.

2. OpenShift Container Platform and Kubernetes are sensitive to disk performance, and faster storage is recommended, particularly for etcd on the control plane nodes which require a 10 ms p99 fsync duration. Note that on many cloud platforms, storage size and IOPS scale together, so you might need to over-allocate storage volume to obtain sufficient performance.

3. As with all user-provisioned installations, if you choose to use RHEL compute machines in your cluster, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks.

Use of RHEL 7 compute machines is deprecated and has been removed in OpenShift Container Platform 4.10 and later.

If an instance type for your platform meets the minimum requirements for cluster machines, it is supported to use in OpenShift Container Platform.

8.10.5.3. Tested instance types for GCP

The following Google Cloud Platform instance types have been tested with OpenShift Container Platform.

Example 8.48. Machine series

- **C2**
- **C2D**
- **C3**
- **E2**
- **M1**
- **N1**
- **N2**
- **N2D**
- **Tau T2D**

8.10.5.4. Using custom machine types

Using a custom machine type to install a OpenShift Container Platform cluster is supported.

Consider the following when using a custom machine type:

- Similar to predefined instance types, custom machine types must meet the minimum resource requirements for control plane and compute machines. For more information, see "Minimum resource requirements for cluster installation".
- The name of the custom machine type must adhere to the following syntax:
  custom-<number_of_cpus>-<amount_of_memory_in_mb>

  For example, **custom-6-20480**.

8.10.6. Creating the installation files for GCP

To install OpenShift Container Platform on Google Cloud Platform (GCP) using user-provisioned infrastructure, you must generate the files that the installation program needs to deploy your cluster and modify them so that the cluster creates only the machines that it will use. You generate and customize the **install-config.yaml** file, Kubernetes manifests, and Ignition config files. You also have the option to first set up a separate **var** partition during the preparation phases of installation.

8.10.6.1. Optional: Creating a separate /var partition

It is recommended that disk partitioning for OpenShift Container Platform be left to the installer. However, there are cases where you might want to create separate partitions in a part of the filesystem that you expect to grow.

OpenShift Container Platform supports the addition of a single partition to attach storage to either the **/var** partition or a subdirectory of **/var**. For example:

- **/var/lib/containers**: Holds container-related content that can grow as more images and containers are added to a system.
- **/var/lib/etcd**: Holds data that you might want to keep separate for purposes such as performance optimization of etcd storage.
- **/var**: Holds data that you might want to keep separate for purposes such as auditing.

Storing the contents of a **/var** directory separately makes it easier to grow storage for those areas as needed and reinstall OpenShift Container Platform at a later date and keep that data intact. With this method, you will not have to pull all your containers again, nor will you have to copy massive log files when you update systems.

Because **/var** must be in place before a fresh installation of Red Hat Enterprise Linux CoreOS (RHCOS), the following procedure sets up the separate **/var** partition by creating a machine config manifest that is inserted during the **openshift-install** preparation phases of an OpenShift Container Platform installation.

IMPORTANT

If you follow the steps to create a separate **/var** partition in this procedure, it is not necessary to create the Kubernetes manifest and Ignition config files again as described later in this section.

Procedure

1. Create a directory to hold the OpenShift Container Platform installation files:

```
$ mkdir $HOME/clusterconfig
```

2. Run **openshift-install** to create a set of files in the **manifest** and **openshift** subdirectories. Answer the system questions as you are prompted:

```
$ openshift-install create manifests --dir $HOME/clusterconfig
```

Example output

```
? SSH Public Key ...
INFO Credentials loaded from the "myprofile" profile in file "/home/myuser/.aws/credentials"
INFO Consuming Install Config from target directory
INFO Manifests created in: $HOME/clusterconfig/manifests and
$HOME/clusterconfig/openshift
```

3. Optional: Confirm that the installation program created manifests in the **clusterconfig/openshift** directory:

```
$ ls $HOME/clusterconfig/openshift/
```

Example output

```
99_kubeadmin-password-secret.yaml
99_openshift-cluster-api_master-machines-0.yaml
99_openshift-cluster-api_master-machines-1.yaml
99_openshift-cluster-api_master-machines-2.yaml
...
```

4. Create a Butane config that configures the additional partition. For example, name the file **$HOME/clusterconfig/98-var-partition.bu**, change the disk device name to the name of the storage device on the **worker** systems, and set the storage size as appropriate. This example places the **/var** directory on a separate partition:

```
variant: openshift
version: 4.11.0
metadata:
  labels:
    machineconfiguration.openshift.io/role: worker
  name: 98-var-partition
storage:
  disks:
  - device: /dev/<device_name> 1
    partitions:
    - label: var
      start_mib: <partition_start_offset> 2
      size_mib: <partition_size> 3
  filesystems:
    - device: /dev/disk/by-partlabel/var
      path: /var
      format: xfs
      mount_options: [defaults, prjquota] 4
      with_mount_unit: true
```

1. The storage device name of the disk that you want to partition.
2. When adding a data partition to the boot disk, a minimum value of 25000 MiB (Mebibytes) is recommended. The root file system is automatically resized to fill all available space up to the specified offset. If no value is specified, or if the specified value is smaller than the recommended minimum, the resulting root file system will be too small, and future reinstalls of RHCOS might overwrite the beginning of the data partition.
3. The size of the data partition in mebibytes.
4. The **prjquota** mount option must be enabled for filesystems used for container storage.

NOTE

When creating a separate **/var** partition, you cannot use different instance types for worker nodes, if the different instance types do not have the same device name.

5. Create a manifest from the Butane config and save it to the **clusterconfig/openshift** directory. For example, run the following command:

```
$ butane $HOME/clusterconfig/98-var-partition.bu -o $HOME/clusterconfig/openshift/98-var-partition.yaml
```

6. Run **openshift-install** again to create Ignition configs from a set of files in the **manifest** and **openshift** subdirectories:

```
$ openshift-install create ignition-configs --dir $HOME/clusterconfig
$ ls $HOME/clusterconfig/
auth  bootstrap.ign  master.ign  metadata.json  worker.ign
```

Now you can use the Ignition config files as input to the installation procedures to install Red Hat Enterprise Linux CoreOS (RHCOS) systems.

8.10.6.2. Creating the installation configuration file

You can customize the OpenShift Container Platform cluster you install on Google Cloud Platform (GCP).

Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.
- Obtain service principal permissions at the subscription level.

Procedure

1. Create the **install-config.yaml** file.
   a. Change to the directory that contains the installation program and run the following command:

```
$ ./openshift-install create install-config --dir <installation_directory> 1
```

   1 For **<installation_directory>**, specify the directory name to store the files that the installation program creates.

   When specifying the directory:

   - Verify that the directory has the **execute** permission. This permission is required to run Terraform binaries under the installation directory.
   - Use an empty directory. Some installation assets, such as bootstrap X.509 certificates, have short expiration intervals, therefore you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

   b. At the prompts, provide the configuration details for your cloud:

i. Optional: Select an SSH key to use to access your cluster machines.

NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

ii. Select **gcp** as the platform to target.

iii. If you have not configured the service account key for your GCP account on your computer, you must obtain it from GCP and paste the contents of the file or enter the absolute path to the file.

iv. Select the project ID to provision the cluster in. The default value is specified by the service account that you configured.

v. Select the region to deploy the cluster to.

vi. Select the base domain to deploy the cluster to. The base domain corresponds to the public DNS zone that you created for your cluster.

vii. Enter a descriptive name for your cluster.

viii. Paste the pull secret from the Red Hat OpenShift Cluster Manager .

c. Optional: If you do not want the cluster to provision compute machines, empty the compute pool by editing the resulting **install-config.yaml** file to set **replicas** to **0** for the **compute** pool:

```
compute:
- hyperthreading: Enabled
  name: worker
  platform: {}
  replicas: 0 1
```

1 Set to **0**.

2. Modify the **install-config.yaml** file. You can find more information about the available parameters in the "Installation configuration parameters" section.

3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.

IMPORTANT

The **install-config.yaml** file is consumed during the installation process. If you want to reuse the file, you must back it up now.

8.10.6.3. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.

NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

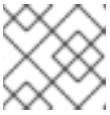
For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
```

1. A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
2. A proxy URL to use for creating HTTPS connections outside the cluster.
3. A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use * to bypass the proxy for all destinations.
4. If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace that contains one or more additional CA certificates that are required for proxying HTTPS connections. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges these contents with the Red Hat Enterprise Linux CoreOS (RHCOS) trust bundle, and this config map is referenced in the **trustedCA** field of the **Proxy** object. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.



NOTE

The installation program does not support the proxy **readinessEndpoints** field.

NOTE

If the installer times out, restart and then complete the deployment by using the **wait-for** command of the installer. For example:

```
$ ./openshift-install wait-for install-complete --log-level debug
```

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.

NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

8.10.6.4. Creating the Kubernetes manifest and Ignition config files

Because you must modify some cluster definition files and manually start the cluster machines, you must generate the Kubernetes manifest and Ignition config files that the cluster needs to configure the machines.

The installation configuration file transforms into the Kubernetes manifests. The manifests wrap into the Ignition configuration files, which are later used to configure the cluster machines.

IMPORTANT

- The Ignition config files that the OpenShift Container Platform installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

Prerequisites

- You obtained the OpenShift Container Platform installation program.
- You created the **install-config.yaml** installation configuration file.

Procedure

1. Change to the directory that contains the OpenShift Container Platform installation program and generate the Kubernetes manifests for the cluster:

```
$ ./openshift-install create manifests --dir <installation_directory> 1
```

1 For **<installation_directory>**, specify the installation directory that contains the **install-config.yaml** file you created.

2. Remove the Kubernetes manifest files that define the control plane machines:

```
$ rm -f <installation_directory>/openshift/99_openshift-cluster-api_master-machines-*.yaml
```

By removing these files, you prevent the cluster from automatically generating control plane machines.

3. Optional: If you do not want the cluster to provision compute machines, remove the Kubernetes manifest files that define the worker machines:

```
$ rm -f <installation_directory>/openshift/99_openshift-cluster-api_worker-machineset-*.yaml
```

Because you create and manage the worker machines yourself, you do not need to initialize these machines.

4. Check that the **mastersSchedulable** parameter in the **<installation_directory>/manifests/cluster-scheduler-02-config.yml** Kubernetes manifest file is set to **false**. This setting prevents pods from being scheduled on the control plane machines:

   a. Open the **<installation_directory>/manifests/cluster-scheduler-02-config.yml** file.

   b. Locate the **mastersSchedulable** parameter and ensure that it is set to **false**.

   c. Save and exit the file.

5. Optional: If you do not want the Ingress Operator to create DNS records on your behalf, remove the **privateZone** and **publicZone** sections from the **<installation_directory>/manifests/cluster-dns-02-config.yml** DNS configuration file:

```
apiVersion: config.openshift.io/v1
kind: DNS
metadata:
  creationTimestamp: null
  name: cluster
spec:
  baseDomain: example.openshift.com
  privateZone: 1
    id: mycluster-100419-private-zone
  publicZone: 2
    id: example.openshift.com
status: {}
```

1 2 Remove this section completely.

If you do so, you must add ingress DNS records manually in a later step.

6. To create the Ignition configuration files, run the following command from the directory that contains the installation program:

```
$ ./openshift-install create ignition-configs --dir <installation_directory> 1
```

1 For **<installation_directory>**, specify the same installation directory.

Ignition config files are created for the bootstrap, control plane, and compute nodes in the installation directory. The **kubeadmin-password** and **kubeconfig** files are created in the **./<installation_directory>/auth** directory:

```
.
├── auth
│   ├── kubeadmin-password
│   └── kubeconfig
├── bootstrap.ign
├── master.ign
├── metadata.json
└── worker.ign
```

Additional resources

- Optional: Adding the ingress DNS records

8.10.7. Exporting common variables

8.10.7.1. Extracting the infrastructure name

The Ignition config files contain a unique cluster identifier that you can use to uniquely identify your cluster in Google Cloud Platform (GCP). The infrastructure name is also used to locate the appropriate GCP resources during an OpenShift Container Platform installation. The provided Deployment Manager templates contain references to this infrastructure name, so you must extract it.

Prerequisites

- You obtained the OpenShift Container Platform installation program and the pull secret for your cluster.
- You generated the Ignition config files for your cluster.
- You installed the **jq** package.

Procedure

- To extract and view the infrastructure name from the Ignition config file metadata, run the following command:

```
$ jq -r .infraID <installation_directory>/metadata.json 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

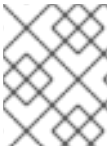
Example output

```
openshift-vw9j6 1
```

1 The output of this command is your cluster name and a random string.

8.10.7.2. Exporting common variables for Deployment Manager templates

You must export a common set of variables that are used with the provided Deployment Manager templates used to assist in completing a user-provided infrastructure install on Google Cloud Platform (GCP).



NOTE

Specific Deployment Manager templates can also require additional exported variables, which are detailed in their related procedures.

Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.
- Generate the Ignition config files for your cluster.
- Install the **jq** package.

Procedure

1. Export the following common variables to be used by the provided Deployment Manager templates:

```
$ export BASE_DOMAIN='<base_domain>'
$ export BASE_DOMAIN_ZONE_NAME='<base_domain_zone_name>'
$ export NETWORK_CIDR='10.0.0.0/16'
$ export MASTER_SUBNET_CIDR='10.0.0.0/17'
$ export WORKER_SUBNET_CIDR='10.0.128.0/17'

$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
$ export CLUSTER_NAME=`jq -r .clusterName <installation_directory>/metadata.json`
$ export INFRA_ID=`jq -r .infraID <installation_directory>/metadata.json`
$ export PROJECT_NAME=`jq -r .gcp.projectID <installation_directory>/metadata.json`
$ export REGION=`jq -r .gcp.region <installation_directory>/metadata.json`
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

8.10.8. Creating a VPC in GCP

You must create a VPC in Google Cloud Platform (GCP) for your OpenShift Container Platform cluster to use. You can customize the VPC to meet your requirements. One way to create the VPC is to modify the provided Deployment Manager template.

NOTE

If you do not use the provided Deployment Manager template to create your GCP infrastructure, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

Prerequisites

- Configure a GCP account.
- Generate the Ignition config files for your cluster.

Procedure

1. Copy the template from the **Deployment Manager template for the VPC**section of this topic and save it as **01_vpc.py** on your computer. This template describes the VPC that your cluster requires.
2. Create a **01_vpc.yaml** resource definition file:

```
$ cat <<EOF >01_vpc.yaml
imports:
- path: 01_vpc.py

resources:
- name: cluster-vpc
  type: 01_vpc.py
  properties:
    infra_id: '${INFRA_ID}' (1)
    region: '${REGION}' (2)
    master_subnet_cidr: '${MASTER_SUBNET_CIDR}' (3)
    worker_subnet_cidr: '${WORKER_SUBNET_CIDR}' (4)
EOF
```

(1) **infra_id** is the **INFRA_ID** infrastructure name from the extraction step.

(2) **region** is the region to deploy the cluster into, for example **us-central1**.

(3) **master_subnet_cidr** is the CIDR for the master subnet, for example **10.0.0.0/17**.

(4) **worker_subnet_cidr** is the CIDR for the worker subnet, for example **10.0.128.0/17**.

3. Create the deployment by using the **gcloud** CLI:

```
$ gcloud deployment-manager deployments create ${INFRA_ID}-vpc --config 01_vpc.yaml
```

8.10.8.1. Deployment Manager template for the VPC

You can use the following Deployment Manager template to deploy the VPC that you need for your OpenShift Container Platform cluster:

Example 8.49. 01_vpc.py Deployment Manager template

```
def GenerateConfig(context):

    resources = [{
        'name': context.properties['infra_id'] + '-network',
        'type': 'compute.v1.network',
        'properties': {
            'region': context.properties['region'],
            'autoCreateSubnetworks': False
        }
    }, {
        'name': context.properties['infra_id'] + '-master-subnet',
        'type': 'compute.v1.subnetwork',
        'properties': {
            'region': context.properties['region'],
            'network': '$(ref.' + context.properties['infra_id'] + '-network.selfLink)',
            'ipCidrRange': context.properties['master_subnet_cidr']
        }
    }, {
        'name': context.properties['infra_id'] + '-worker-subnet',
        'type': 'compute.v1.subnetwork',
        'properties': {
            'region': context.properties['region'],
            'network': '$(ref.' + context.properties['infra_id'] + '-network.selfLink)',
            'ipCidrRange': context.properties['worker_subnet_cidr']
        }
    }, {
        'name': context.properties['infra_id'] + '-router',
        'type': 'compute.v1.router',
        'properties': {
            'region': context.properties['region'],
            'network': '$(ref.' + context.properties['infra_id'] + '-network.selfLink)',
            'nats': [{
                'name': context.properties['infra_id'] + '-nat-master',
                'natIpAllocateOption': 'AUTO_ONLY',
                'minPortsPerVm': 7168,
                'sourceSubnetworkIpRangesToNat': 'LIST_OF_SUBNETWORKS',
                'subnetworks': [{
                    'name': '$(ref.' + context.properties['infra_id'] + '-master-subnet.selfLink)',
                    'sourceIpRangesToNat': ['ALL_IP_RANGES']
                }]
            }, {
                'name': context.properties['infra_id'] + '-nat-worker',
                'natIpAllocateOption': 'AUTO_ONLY',
                'minPortsPerVm': 512,
                'sourceSubnetworkIpRangesToNat': 'LIST_OF_SUBNETWORKS',
                'subnetworks': [{
                    'name': '$(ref.' + context.properties['infra_id'] + '-worker-subnet.selfLink)',
                    'sourceIpRangesToNat': ['ALL_IP_RANGES']
                }]
            }]
        }
    }]

    return {'resources': resources}
```

8.10.9. Networking requirements for user-provisioned infrastructure

All the Red Hat Enterprise Linux CoreOS (RHCOS) machines require networking to be configured in **initramfs** during boot to fetch their Ignition config files.

8.10.9.1. Setting the cluster node hostnames through DHCP

On Red Hat Enterprise Linux CoreOS (RHCOS) machines, the hostname is set through NetworkManager. By default, the machines obtain their hostname through DHCP. If the hostname is not provided by DHCP, set statically through kernel arguments, or another method, it is obtained through a reverse DNS lookup. Reverse DNS lookup occurs after the network has been initialized on a node and can take time to resolve. Other system services can start prior to this and detect the hostname as **localhost** or similar. You can avoid this by using DHCP to provide the hostname for each cluster node.

Additionally, setting the hostnames through DHCP can bypass any manual DNS record name configuration errors in environments that have a DNS split-horizon implementation.

8.10.9.2. Network connectivity requirements

You must configure the network connectivity between machines to allow OpenShift Container Platform cluster components to communicate. Each machine must be able to resolve the hostnames of all other machines in the cluster.

This section provides details about the ports that are required.

IMPORTANT

In connected OpenShift Container Platform environments, all nodes are required to have internet access to pull images for platform containers and provide telemetry data to Red Hat.

Table 8.43. Ports used for all-machine to all-machine communications

Protocol	Port	Description
ICMP	N/A	Network reachability tests
TCP	**1936**	Metrics
	9000-**9999**	Host level services, including the node exporter on ports **9100**-**9101** and the Cluster Version Operator on port**9099**.
	10250-**10259**	The default ports that Kubernetes reserves
	10256	openshift-sdn
UDP	**4789**	VXLAN
	6081	Geneve

Protocol	Port	Description
	9000-**9999**	Host level services, including the node exporter on ports **9100**-**9101**.
	500	IPsec IKE packets
	4500	IPsec NAT-T packets
TCP/UDP	**30000**-**32767**	Kubernetes node port
ESP	N/A	IPsec Encapsulating Security Payload (ESP)

Table 8.44. Ports used for all-machine to control plane communications

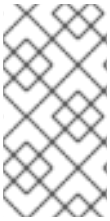
Protocol	Port	Description
TCP	**6443**	Kubernetes API

Table 8.45. Ports used for control plane machine to control plane machine communications

Protocol	Port	Description
TCP	**2379**-**2380**	etcd server and peer ports

8.10.10. Creating load balancers in GCP

You must configure load balancers in Google Cloud Platform (GCP) for your OpenShift Container Platform cluster to use. One way to create these components is to modify the provided Deployment Manager template.



NOTE

If you do not use the provided Deployment Manager template to create your GCP infrastructure, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

Prerequisites

- Configure a GCP account.
- Generate the Ignition config files for your cluster.
- Create and configure a VPC and associated subnets in GCP.

Procedure

1. Copy the template from the **Deployment Manager template for the internal load balancer**

1. Copy the template from the **Deployment Manager template for the internal load balancer** section of this topic and save it as **02_lb_int.py** on your computer. This template describes the internal load balancing objects that your cluster requires.

2. For an external cluster, also copy the template from the **Deployment Manager template for the external load balancer** section of this topic and save it as **02_lb_ext.py** on your computer. This template describes the external load balancing objects that your cluster requires.

3. Export the variables that the deployment template uses:

   a. Export the cluster network location:

   ```
   $ export CLUSTER_NETWORK=(`gcloud compute networks describe ${INFRA_ID}-network --format json | jq -r .selfLink`)
   ```

   b. Export the control plane subnet location:

   ```
   $ export CONTROL_SUBNET=(`gcloud compute networks subnets describe ${INFRA_ID}-master-subnet --region=${REGION} --format json | jq -r .selfLink`)
   ```

   c. Export the three zones that the cluster uses:

   ```
   $ export ZONE_0=(`gcloud compute regions describe ${REGION} --format=json | jq -r .zones[0] | cut -d "/" -f9`)
   ```

   ```
   $ export ZONE_1=(`gcloud compute regions describe ${REGION} --format=json | jq -r .zones[1] | cut -d "/" -f9`)
   ```

   ```
   $ export ZONE_2=(`gcloud compute regions describe ${REGION} --format=json | jq -r .zones[2] | cut -d "/" -f9`)
   ```

4. Create a **02_infra.yaml** resource definition file:

```
$ cat <<EOF >02_infra.yaml
imports:
- path: 02_lb_ext.py
- path: 02_lb_int.py (1)
resources:
- name: cluster-lb-ext (2)
  type: 02_lb_ext.py
  properties:
    infra_id: '${INFRA_ID}' (3)
    region: '${REGION}' (4)
- name: cluster-lb-int
  type: 02_lb_int.py
  properties:
    cluster_network: '${CLUSTER_NETWORK}'
    control_subnet: '${CONTROL_SUBNET}' (5)
    infra_id: '${INFRA_ID}'
    region: '${REGION}'
    zones: (6)
    - '${ZONE_0}'
```

```
    - '${ZONE_1}'
    - '${ZONE_2}'
EOF
```

1 2 Required only when deploying an external cluster.

3 **infra_id** is the **INFRA_ID** infrastructure name from the extraction step.

4 **region** is the region to deploy the cluster into, for example **us-central1**.

5 **control_subnet** is the URI to the control subnet.

6 **zones** are the zones to deploy the control plane instances into, like **us-east1-b**, **us-east1-c**, and **us-east1-d**.

5. Create the deployment by using the **gcloud** CLI:

```
$ gcloud deployment-manager deployments create ${INFRA_ID}-infra --config 02_infra.yaml
```

6. Export the cluster IP address:

```
$ export CLUSTER_IP=(`gcloud compute addresses describe ${INFRA_ID}-cluster-ip --region=${REGION} --format json | jq -r .address`)
```

7. For an external cluster, also export the cluster public IP address:

```
$ export CLUSTER_PUBLIC_IP=(`gcloud compute addresses describe ${INFRA_ID}-cluster-public-ip --region=${REGION} --format json | jq -r .address`)
```

8.10.10.1. Deployment Manager template for the external load balancer

You can use the following Deployment Manager template to deploy the external load balancer that you need for your OpenShift Container Platform cluster:

Example 8.50. 02_lb_ext.py Deployment Manager template

```
def GenerateConfig(context):

    resources = [{
        'name': context.properties['infra_id'] + '-cluster-public-ip',
        'type': 'compute.v1.address',
        'properties': {
            'region': context.properties['region']
        }
    }, {
        # Refer to docs/dev/kube-apiserver-health-check.md on how to correctly setup health check probe for kube-apiserver
        'name': context.properties['infra_id'] + '-api-http-health-check',
        'type': 'compute.v1.httpHealthCheck',
        'properties': {
            'port': 6080,
            'requestPath': '/readyz'
        }
```

```
    }, {
        'name': context.properties['infra_id'] + '-api-target-pool',
        'type': 'compute.v1.targetPool',
        'properties': {
            'region': context.properties['region'],
            'healthChecks': ['$(ref.' + context.properties['infra_id'] + '-api-http-health-check.selfLink)'],
            'instances': []
        }
    }, {
        'name': context.properties['infra_id'] + '-api-forwarding-rule',
        'type': 'compute.v1.forwardingRule',
        'properties': {
            'region': context.properties['region'],
            'IPAddress': '$(ref.' + context.properties['infra_id'] + '-cluster-public-ip.selfLink)',
            'target': '$(ref.' + context.properties['infra_id'] + '-api-target-pool.selfLink)',
            'portRange': '6443'
        }
    }]

    return {'resources': resources}
```

8.10.10.2. Deployment Manager template for the internal load balancer

You can use the following Deployment Manager template to deploy the internal load balancer that you need for your OpenShift Container Platform cluster:

Example 8.51. 02_lb_int.py Deployment Manager template

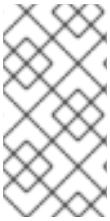
```
def GenerateConfig(context):

    backends = []
    for zone in context.properties['zones']:
        backends.append({
            'group': '$(ref.' + context.properties['infra_id'] + '-master-' + zone + '-ig' + '.selfLink)'
        })

    resources = [{
        'name': context.properties['infra_id'] + '-cluster-ip',
        'type': 'compute.v1.address',
        'properties': {
            'addressType': 'INTERNAL',
            'region': context.properties['region'],
            'subnetwork': context.properties['control_subnet']
        }
    }, {
        # Refer to docs/dev/kube-apiserver-health-check.md on how to correctly setup health check probe for kube-apiserver
        'name': context.properties['infra_id'] + '-api-internal-health-check',
        'type': 'compute.v1.healthCheck',
        'properties': {
            'httpsHealthCheck': {
                'port': 6443,
                'requestPath': '/readyz'
            },
```

```
            'type': "HTTPS"
        }
    }, {
        'name': context.properties['infra_id'] + '-api-internal-backend-service',
        'type': 'compute.v1.regionBackendService',
        'properties': {
            'backends': backends,
            'healthChecks': ['$(ref.' + context.properties['infra_id'] + '-api-internal-health-
check.selfLink)'],
            'loadBalancingScheme': 'INTERNAL',
            'region': context.properties['region'],
            'protocol': 'TCP',
            'timeoutSec': 120
        }
    }, {
        'name': context.properties['infra_id'] + '-api-internal-forwarding-rule',
        'type': 'compute.v1.forwardingRule',
        'properties': {
            'backendService': '$(ref.' + context.properties['infra_id'] + '-api-internal-backend-
service.selfLink)',
            'IPAddress': '$(ref.' + context.properties['infra_id'] + '-cluster-ip.selfLink)',
            'loadBalancingScheme': 'INTERNAL',
            'ports': ['6443','22623'],
            'region': context.properties['region'],
            'subnetwork': context.properties['control_subnet']
        }
    }]

    for zone in context.properties['zones']:
        resources.append({
            'name': context.properties['infra_id'] + '-master-' + zone + '-ig',
            'type': 'compute.v1.instanceGroup',
            'properties': {
                'namedPorts': [
                    {
                        'name': 'ignition',
                        'port': 22623
                    }, {
                        'name': 'https',
                        'port': 6443
                    }
                ],
                'network': context.properties['cluster_network'],
                'zone': zone
            }
        })

    return {'resources': resources}
```

You will need this template in addition to the **02_lb_ext.py** template when you create an external cluster.

8.10.11. Creating a private DNS zone in GCP

You must configure a private DNS zone in Google Cloud Platform (GCP) for your OpenShift Container Platform cluster to use. One way to create this component is to modify the provided Deployment Manager template.



NOTE

If you do not use the provided Deployment Manager template to create your GCP infrastructure, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

Prerequisites

- Configure a GCP account.
- Generate the Ignition config files for your cluster.
- Create and configure a VPC and associated subnets in GCP.

Procedure

1. Copy the template from the **Deployment Manager template for the private DNS**section of this topic and save it as **02_dns.py** on your computer. This template describes the private DNS objects that your cluster requires.
2. Create a **02_dns.yaml** resource definition file:

```
$ cat <<EOF >02_dns.yaml
imports:
- path: 02_dns.py

resources:
- name: cluster-dns
  type: 02_dns.py
  properties:
    infra_id: '${INFRA_ID}' (1)
    cluster_domain: '${CLUSTER_NAME}.${BASE_DOMAIN}' (2)
    cluster_network: '${CLUSTER_NETWORK}' (3)
EOF
```

(1) **infra_id** is the **INFRA_ID** infrastructure name from the extraction step.

(2) **cluster_domain** is the domain for the cluster, for example **openshift.example.com**.

(3) **cluster_network** is the **selfLink** URL to the cluster network.

3. Create the deployment by using the **gcloud** CLI:

```
$ gcloud deployment-manager deployments create ${INFRA_ID}-dns --config 02_dns.yaml
```

4. The templates do not create DNS entries due to limitations of Deployment Manager, so you must create them manually:
   a. Add the internal DNS entries:

```
$ if [ -f transaction.yaml ]; then rm transaction.yaml; fi
$ gcloud dns record-sets transaction start --zone ${INFRA_ID}-private-zone
$ gcloud dns record-sets transaction add ${CLUSTER_IP} --name
api.${CLUSTER_NAME}.${BASE_DOMAIN}. --ttl 60 --type A --zone ${INFRA_ID}-
private-zone
$ gcloud dns record-sets transaction add ${CLUSTER_IP} --name api-
int.${CLUSTER_NAME}.${BASE_DOMAIN}. --ttl 60 --type A --zone ${INFRA_ID}-
private-zone
$ gcloud dns record-sets transaction execute --zone ${INFRA_ID}-private-zone
```

b. For an external cluster, also add the external DNS entries:

```
$ if [ -f transaction.yaml ]; then rm transaction.yaml; fi
$ gcloud dns record-sets transaction start --zone ${BASE_DOMAIN_ZONE_NAME}
$ gcloud dns record-sets transaction add ${CLUSTER_PUBLIC_IP} --name
api.${CLUSTER_NAME}.${BASE_DOMAIN}. --ttl 60 --type A --zone
${BASE_DOMAIN_ZONE_NAME}
$ gcloud dns record-sets transaction execute --zone ${BASE_DOMAIN_ZONE_NAME}
```

8.10.11.1. Deployment Manager template for the private DNS

You can use the following Deployment Manager template to deploy the private DNS that you need for your OpenShift Container Platform cluster:

Example 8.52. 02_dns.py Deployment Manager template

```
def GenerateConfig(context):

    resources = [{
        'name': context.properties['infra_id'] + '-private-zone',
        'type': 'dns.v1.managedZone',
        'properties': {
            'description': '',
            'dnsName': context.properties['cluster_domain'] + '.',
            'visibility': 'private',
            'privateVisibilityConfig': {
                'networks': [{
                    'networkUrl': context.properties['cluster_network']
                }]
            }
        }
    }]

    return {'resources': resources}
```

8.10.12. Creating firewall rules in GCP

You must create firewall rules in Google Cloud Platform (GCP) for your OpenShift Container Platform cluster to use. One way to create these components is to modify the provided Deployment Manager template.

NOTE

If you do not use the provided Deployment Manager template to create your GCP infrastructure, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

Prerequisites

- Configure a GCP account.
- Generate the Ignition config files for your cluster.
- Create and configure a VPC and associated subnets in GCP.

Procedure

1. Copy the template from the **Deployment Manager template for firewall rules**section of this topic and save it as **03_firewall.py** on your computer. This template describes the security groups that your cluster requires.
2. Create a **03_firewall.yaml** resource definition file:

```
$ cat <<EOF >03_firewall.yaml
imports:
- path: 03_firewall.py

resources:
- name: cluster-firewall
  type: 03_firewall.py
  properties:
    allowed_external_cidr: '0.0.0.0/0' (1)
    infra_id: '${INFRA_ID}' (2)
    cluster_network: '${CLUSTER_NETWORK}' (3)
    network_cidr: '${NETWORK_CIDR}' (4)
EOF
```

(1) **allowed_external_cidr** is the CIDR range that can access the cluster API and SSH to the bootstrap host. For an internal cluster, set this value to **${NETWORK_CIDR}**.

(2) **infra_id** is the **INFRA_ID** infrastructure name from the extraction step.

(3) **cluster_network** is the **selfLink** URL to the cluster network.

(4) **network_cidr** is the CIDR of the VPC network, for example **10.0.0.0/16**.

3. Create the deployment by using the **gcloud** CLI:

```
$ gcloud deployment-manager deployments create ${INFRA_ID}-firewall --config
03_firewall.yaml
```

8.10.12.1. Deployment Manager template for firewall rules

You can use the following Deployment Manager template to deploy the firewall rues that you need for your OpenShift Container Platform cluster:

Example 8.53. 03_firewall.py Deployment Manager template

```
def GenerateConfig(context):

    resources = [{
        'name': context.properties['infra_id'] + '-bootstrap-in-ssh',
        'type': 'compute.v1.firewall',
        'properties': {
            'network': context.properties['cluster_network'],
            'allowed': [{
                'IPProtocol': 'tcp',
                'ports': ['22']
            }],
            'sourceRanges': [context.properties['allowed_external_cidr']],
            'targetTags': [context.properties['infra_id'] + '-bootstrap']
        }
    }, {
        'name': context.properties['infra_id'] + '-api',
        'type': 'compute.v1.firewall',
        'properties': {
            'network': context.properties['cluster_network'],
            'allowed': [{
                'IPProtocol': 'tcp',
                'ports': ['6443']
            }],
            'sourceRanges': [context.properties['allowed_external_cidr']],
            'targetTags': [context.properties['infra_id'] + '-master']
        }
    }, {
        'name': context.properties['infra_id'] + '-health-checks',
        'type': 'compute.v1.firewall',
        'properties': {
            'network': context.properties['cluster_network'],
            'allowed': [{
                'IPProtocol': 'tcp',
                'ports': ['6080', '6443', '22624']
            }],
            'sourceRanges': ['35.191.0.0/16', '130.211.0.0/22', '209.85.152.0/22', '209.85.204.0/22'],
            'targetTags': [context.properties['infra_id'] + '-master']
        }
    }, {
        'name': context.properties['infra_id'] + '-etcd',
        'type': 'compute.v1.firewall',
        'properties': {
            'network': context.properties['cluster_network'],
            'allowed': [{
                'IPProtocol': 'tcp',
                'ports': ['2379-2380']
            }],
            'sourceTags': [context.properties['infra_id'] + '-master'],
            'targetTags': [context.properties['infra_id'] + '-master']
        }
    }, {
```

```
        'name': context.properties['infra_id'] + '-control-plane',
        'type': 'compute.v1.firewall',
        'properties': {
            'network': context.properties['cluster_network'],
            'allowed': [{
                'IPProtocol': 'tcp',
                'ports': ['10257']
            },{
                'IPProtocol': 'tcp',
                'ports': ['10259']
            },{
                'IPProtocol': 'tcp',
                'ports': ['22623']
            }],
            'sourceTags': [
                context.properties['infra_id'] + '-master',
                context.properties['infra_id'] + '-worker'
            ],
            'targetTags': [context.properties['infra_id'] + '-master']
        }
    }, {
        'name': context.properties['infra_id'] + '-internal-network',
        'type': 'compute.v1.firewall',
        'properties': {
            'network': context.properties['cluster_network'],
            'allowed': [{
                'IPProtocol': 'icmp'
            },{
                'IPProtocol': 'tcp',
                'ports': ['22']
            }],
            'sourceRanges': [context.properties['network_cidr']],
            'targetTags': [
                context.properties['infra_id'] + '-master',
                context.properties['infra_id'] + '-worker'
            ]
        }
    }, {
        'name': context.properties['infra_id'] + '-internal-cluster',
        'type': 'compute.v1.firewall',
        'properties': {
            'network': context.properties['cluster_network'],
            'allowed': [{
                'IPProtocol': 'udp',
                'ports': ['4789', '6081']
            },{
                'IPProtocol': 'udp',
                'ports': ['500', '4500']
            },{
                'IPProtocol': 'esp',
            },{
                'IPProtocol': 'tcp',
                'ports': ['9000-9999']
            },{
                'IPProtocol': 'udp',
                'ports': ['9000-9999']
```

```
            },{
                'IPProtocol': 'tcp',
                'ports': ['10250']
            },{
                'IPProtocol': 'tcp',
                'ports': ['30000-32767']
            },{
                'IPProtocol': 'udp',
                'ports': ['30000-32767']
            }],
            'sourceTags': [
                context.properties['infra_id'] + '-master',
                context.properties['infra_id'] + '-worker'
            ],
            'targetTags': [
                context.properties['infra_id'] + '-master',
                context.properties['infra_id'] + '-worker'
            ]
        }
    }]

    return {'resources': resources}
```

8.10.13. Creating IAM roles in GCP

You must create IAM roles in Google Cloud Platform (GCP) for your OpenShift Container Platform cluster to use. One way to create these components is to modify the provided Deployment Manager template.

NOTE

If you do not use the provided Deployment Manager template to create your GCP infrastructure, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

Prerequisites

- Configure a GCP account.
- Generate the Ignition config files for your cluster.
- Create and configure a VPC and associated subnets in GCP.

Procedure

1. Copy the template from the **Deployment Manager template for IAM roles**section of this topic and save it as **03_iam.py** on your computer. This template describes the IAM roles that your cluster requires.
2. Create a **03_iam.yaml** resource definition file:

```
$ cat <<EOF >03_iam.yaml
```

```
imports:
- path: 03_iam.py
resources:
- name: cluster-iam
  type: 03_iam.py
  properties:
    infra_id: '${INFRA_ID}' 1
EOF
```

1 **infra_id** is the **INFRA_ID** infrastructure name from the extraction step.

3. Create the deployment by using the **gcloud** CLI:

```
$ gcloud deployment-manager deployments create ${INFRA_ID}-iam --config 03_iam.yaml
```

4. Export the variable for the master service account:

```
$ export MASTER_SERVICE_ACCOUNT=(`gcloud iam service-accounts list --filter
"email~^${INFRA_ID}-m@${PROJECT_NAME}." --format json | jq -r '.[0].email'`)
```

5. Export the variable for the worker service account:

```
$ export WORKER_SERVICE_ACCOUNT=(`gcloud iam service-accounts list --filter
"email~^${INFRA_ID}-w@${PROJECT_NAME}." --format json | jq -r '.[0].email'`)
```

6. Export the variable for the subnet that hosts the compute machines:

```
$ export COMPUTE_SUBNET=(`gcloud compute networks subnets describe ${INFRA_ID}-
worker-subnet --region=${REGION} --format json | jq -r .selfLink`)
```

7. The templates do not create the policy bindings due to limitations of Deployment Manager, so you must create them manually:

```
$ gcloud projects add-iam-policy-binding ${PROJECT_NAME} --member
"serviceAccount:${MASTER_SERVICE_ACCOUNT}" --role "roles/compute.instanceAdmin"
$ gcloud projects add-iam-policy-binding ${PROJECT_NAME} --member
"serviceAccount:${MASTER_SERVICE_ACCOUNT}" --role "roles/compute.networkAdmin"
$ gcloud projects add-iam-policy-binding ${PROJECT_NAME} --member
"serviceAccount:${MASTER_SERVICE_ACCOUNT}" --role "roles/compute.securityAdmin"
$ gcloud projects add-iam-policy-binding ${PROJECT_NAME} --member
"serviceAccount:${MASTER_SERVICE_ACCOUNT}" --role "roles/iam.serviceAccountUser"
$ gcloud projects add-iam-policy-binding ${PROJECT_NAME} --member
"serviceAccount:${MASTER_SERVICE_ACCOUNT}" --role "roles/storage.admin"

$ gcloud projects add-iam-policy-binding ${PROJECT_NAME} --member
"serviceAccount:${WORKER_SERVICE_ACCOUNT}" --role "roles/compute.viewer"
$ gcloud projects add-iam-policy-binding ${PROJECT_NAME} --member
"serviceAccount:${WORKER_SERVICE_ACCOUNT}" --role "roles/storage.admin"
```

8. Create a service account key and store it locally for later use:

```
$ gcloud iam service-accounts keys create service-account-key.json --iam-
account=${MASTER_SERVICE_ACCOUNT}
```

-

8.10.13.1. Deployment Manager template for IAM roles

You can use the following Deployment Manager template to deploy the IAM roles that you need for your OpenShift Container Platform cluster:

Example 8.54. 03_iam.py Deployment Manager template

```
def GenerateConfig(context):

    resources = [{
        'name': context.properties['infra_id'] + '-master-node-sa',
        'type': 'iam.v1.serviceAccount',
        'properties': {
            'accountId': context.properties['infra_id'] + '-m',
            'displayName': context.properties['infra_id'] + '-master-node'
        }
    }, {
        'name': context.properties['infra_id'] + '-worker-node-sa',
        'type': 'iam.v1.serviceAccount',
        'properties': {
            'accountId': context.properties['infra_id'] + '-w',
            'displayName': context.properties['infra_id'] + '-worker-node'
        }
    }]

    return {'resources': resources}
```

8.10.14. Creating the RHCOS cluster image for the GCP infrastructure

You must use a valid Red Hat Enterprise Linux CoreOS (RHCOS) image for Google Cloud Platform (GCP) for your OpenShift Container Platform nodes.

Procedure

1. Obtain the RHCOS image from the RHCOS image mirror page.

IMPORTANT

The RHCOS images might not change with every release of OpenShift Container Platform. You must download an image with the highest version that is less than or equal to the OpenShift Container Platform version that you install. Use the image version that matches your OpenShift Container Platform version if it is available.

The file name contains the OpenShift Container Platform version number in the format **rhcos-<version>-<arch>-gcp.<arch>.tar.gz**.

2. Create the Google storage bucket:

```
$ gsutil mb gs://<bucket_name>
```

3. Upload the RHCOS image to the Google storage bucket:

```
$ gsutil cp <downloaded_image_file_path>/rhcos-<version>-x86_64-gcp.x86_64.tar.gz
gs://<bucket_name>
```

4. Export the uploaded RHCOS image location as a variable:

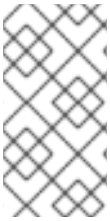
```
$ export IMAGE_SOURCE=gs://<bucket_name>/rhcos-<version>-x86_64-gcp.x86_64.tar.gz
```

5. Create the cluster image:

```
$ gcloud compute images create "${INFRA_ID}-rhcos-image" \
    --source-uri="${IMAGE_SOURCE}"
```

8.10.15. Creating the bootstrap machine in GCP

You must create the bootstrap machine in Google Cloud Platform (GCP) to use during OpenShift Container Platform cluster initialization. One way to create this machine is to modify the provided Deployment Manager template.



NOTE

If you do not use the provided Deployment Manager template to create your bootstrap machine, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

Prerequisites

- Configure a GCP account.
- Generate the Ignition config files for your cluster.
- Create and configure a VPC and associated subnets in GCP.
- Create and configure networking and load balancers in GCP.
- Create control plane and compute roles.
- Ensure pyOpenSSL is installed.

Procedure

1. Copy the template from the **Deployment Manager template for the bootstrap machine** section of this topic and save it as **04_bootstrap.py** on your computer. This template describes the bootstrap machine that your cluster requires.

2. Export the location of the Red Hat Enterprise Linux CoreOS (RHCOS) image that the installation program requires:

```
$ export CLUSTER_IMAGE=(`gcloud compute images describe ${INFRA_ID}-rhcos-image --
format json | jq -r .selfLink`)
```

3. Create a bucket and upload the **bootstrap.ign** file:

```
$ gsutil mb gs://${INFRA_ID}-bootstrap-ignition
```

```
$ gsutil cp <installation_directory>/bootstrap.ign gs://${INFRA_ID}-bootstrap-ignition/
```

4. Create a signed URL for the bootstrap instance to use to access the Ignition config. Export the URL from the output as a variable:

```
$ export BOOTSTRAP_IGN=`gsutil signurl -d 1h service-account-key.json gs://${INFRA_ID}-bootstrap-ignition/bootstrap.ign | grep "^gs:" | awk '{print $5}'`
```

5. Create a **04_bootstrap.yaml** resource definition file:

```
$ cat <<EOF >04_bootstrap.yaml
imports:
- path: 04_bootstrap.py

resources:
- name: cluster-bootstrap
  type: 04_bootstrap.py
  properties:
    infra_id: '${INFRA_ID}' 1
    region: '${REGION}' 2
    zone: '${ZONE_0}' 3

    cluster_network: '${CLUSTER_NETWORK}' 4
    control_subnet: '${CONTROL_SUBNET}' 5
    image: '${CLUSTER_IMAGE}' 6
    machine_type: 'n1-standard-4' 7
    root_volume_size: '128' 8

    bootstrap_ign: '${BOOTSTRAP_IGN}' 9
EOF
```

1. **infra_id** is the **INFRA_ID** infrastructure name from the extraction step.
2. **region** is the region to deploy the cluster into, for example **us-central1**.
3. **zone** is the zone to deploy the bootstrap instance into, for example **us-central1-b**.
4. **cluster_network** is the **selfLink** URL to the cluster network.
5. **control_subnet** is the **selfLink** URL to the control subnet.
6. **image** is the **selfLink** URL to the RHCOS image.
7. **machine_type** is the machine type of the instance, for example **n1-standard-4**.
8. **root_volume_size** is the boot disk size for the bootstrap machine.
9. **bootstrap_ign** is the URL output when creating a signed URL.

6. Create the deployment by using the **gcloud** CLI:

```
$ gcloud deployment-manager deployments create ${INFRA_ID}-bootstrap --config
04_bootstrap.yaml
```

7. The templates do not manage load balancer membership due to limitations of Deployment Manager, so you must add the bootstrap machine manually.

   a. Add the bootstrap instance to the internal load balancer instance group:

   ```
   $ gcloud compute instance-groups unmanaged add-instances \
     ${INFRA_ID}-bootstrap-ig --zone=${ZONE_0} --instances=${INFRA_ID}-bootstrap
   ```

   b. Add the bootstrap instance group to the internal load balancer backend service:

   ```
   $ gcloud compute backend-services add-backend \
     ${INFRA_ID}-api-internal-backend-service --region=${REGION} --instance-
   group=${INFRA_ID}-bootstrap-ig --instance-group-zone=${ZONE_0}
   ```

8.10.15.1. Deployment Manager template for the bootstrap machine

You can use the following Deployment Manager template to deploy the bootstrap machine that you need for your OpenShift Container Platform cluster:

Example 8.55. 04_bootstrap.py Deployment Manager template

```
def GenerateConfig(context):

    resources = [{
        'name': context.properties['infra_id'] + '-bootstrap-public-ip',
        'type': 'compute.v1.address',
        'properties': {
            'region': context.properties['region']
        }
    }, {
        'name': context.properties['infra_id'] + '-bootstrap',
        'type': 'compute.v1.instance',
        'properties': {
            'disks': [{
                'autoDelete': True,
                'boot': True,
                'initializeParams': {
                    'diskSizeGb': context.properties['root_volume_size'],
                    'sourceImage': context.properties['image']
                }
            }],
            'machineType': 'zones/' + context.properties['zone'] + '/machineTypes/' +
context.properties['machine_type'],
            'metadata': {
                'items': [{
                    'key': 'user-data',
                    'value': '{"ignition":{"config":{"replace":{"source":"' + context.properties['bootstrap_ign']
+ '"}},"version":"3.2.0"}}',
                }]
            },
            'networkInterfaces': [{
```

```
            'subnetwork': context.properties['control_subnet'],
            'accessConfigs': [{
                'natIP': '$(ref.' + context.properties['infra_id'] + '-bootstrap-public-ip.address)'
            }]
        }],
        'tags': {
            'items': [
                context.properties['infra_id'] + '-master',
                context.properties['infra_id'] + '-bootstrap'
            ]
        },
        'zone': context.properties['zone']
    }
}, {
    'name': context.properties['infra_id'] + '-bootstrap-ig',
    'type': 'compute.v1.instanceGroup',
    'properties': {
        'namedPorts': [
            {
                'name': 'ignition',
                'port': 22623
            }, {
                'name': 'https',
                'port': 6443
            }
        ],
        'network': context.properties['cluster_network'],
        'zone': context.properties['zone']
    }
}]

return {'resources': resources}
```

8.10.16. Creating the control plane machines in GCP

You must create the control plane machines in Google Cloud Platform (GCP) for your cluster to use. One way to create these machines is to modify the provided Deployment Manager template.

NOTE

If you do not use the provided Deployment Manager template to create your control plane machines, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

Prerequisites

- Configure a GCP account.
- Generate the Ignition config files for your cluster.
- Create and configure a VPC and associated subnets in GCP.
- Create and configure networking and load balancers in GCP.

- Create control plane and compute roles.
- Create the bootstrap machine.

Procedure

1. Copy the template from the **Deployment Manager template for control plane machines** section of this topic and save it as **05_control_plane.py** on your computer. This template describes the control plane machines that your cluster requires.
2. Export the following variable required by the resource definition:

```
$ export MASTER_IGNITION=`cat <installation_directory>/master.ign`
```

3. Create a **05_control_plane.yaml** resource definition file:

```
$ cat <<EOF >05_control_plane.yaml
imports:
- path: 05_control_plane.py

resources:
- name: cluster-control-plane
  type: 05_control_plane.py
  properties:
    infra_id: '${INFRA_ID}' (1)
    zones: (2)
    - '${ZONE_0}'
    - '${ZONE_1}'
    - '${ZONE_2}'

    control_subnet: '${CONTROL_SUBNET}' (3)
    image: '${CLUSTER_IMAGE}' (4)
    machine_type: 'n1-standard-4' (5)
    root_volume_size: '128'
    service_account_email: '${MASTER_SERVICE_ACCOUNT}' (6)

    ignition: '${MASTER_IGNITION}' (7)
EOF
```

(1) **infra_id** is the **INFRA_ID** infrastructure name from the extraction step.

(2) **zones** are the zones to deploy the control plane instances into, for example **us-central1-a**, **us-central1-b**, and **us-central1-c**.

(3) **control_subnet** is the **selfLink** URL to the control subnet.

(4) **image** is the **selfLink** URL to the RHCOS image.

(5) **machine_type** is the machine type of the instance, for example **n1-standard-4**.

(6) **service_account_email** is the email address for the master service account that you created.

(7) **ignition** is the contents of the **master.ign** file.

4. Create the deployment by using the **gcloud** CLI:

```
$ gcloud deployment-manager deployments create ${INFRA_ID}-control-plane --config
05_control_plane.yaml
```

5. The templates do not manage load balancer membership due to limitations of Deployment Manager, so you must add the control plane machines manually.

   - Run the following commands to add the control plane machines to the appropriate instance groups:

```
$ gcloud compute instance-groups unmanaged add-instances ${INFRA_ID}-master-
${ZONE_0}-ig --zone=${ZONE_0} --instances=${INFRA_ID}-master-0
```

```
$ gcloud compute instance-groups unmanaged add-instances ${INFRA_ID}-master-
${ZONE_1}-ig --zone=${ZONE_1} --instances=${INFRA_ID}-master-1
```

```
$ gcloud compute instance-groups unmanaged add-instances ${INFRA_ID}-master-
${ZONE_2}-ig --zone=${ZONE_2} --instances=${INFRA_ID}-master-2
```

   - For an external cluster, you must also run the following commands to add the control plane machines to the target pools:

```
$ gcloud compute target-pools add-instances ${INFRA_ID}-api-target-pool --instances-
zone="${ZONE_0}" --instances=${INFRA_ID}-master-0
```

```
$ gcloud compute target-pools add-instances ${INFRA_ID}-api-target-pool --instances-
zone="${ZONE_1}" --instances=${INFRA_ID}-master-1
```

```
$ gcloud compute target-pools add-instances ${INFRA_ID}-api-target-pool --instances-
zone="${ZONE_2}" --instances=${INFRA_ID}-master-2
```

8.10.16.1. Deployment Manager template for control plane machines

You can use the following Deployment Manager template to deploy the control plane machines that you need for your OpenShift Container Platform cluster:

Example 8.56. 05_control_plane.py Deployment Manager template

```
def GenerateConfig(context):

    resources = [{
        'name': context.properties['infra_id'] + '-master-0',
        'type': 'compute.v1.instance',
        'properties': {
            'disks': [{
                'autoDelete': True,
                'boot': True,
                'initializeParams': {
                    'diskSizeGb': context.properties['root_volume_size'],
                    'diskType': 'zones/' + context.properties['zones'][0] + '/diskTypes/pd-ssd',
                    'sourceImage': context.properties['image']
```

```
            }
        }],
        'machineType': 'zones/' + context.properties['zones'][0] + '/machineTypes/' +
context.properties['machine_type'],
        'metadata': {
            'items': [{
                'key': 'user-data',
                'value': context.properties['ignition']
            }]
        },
        'networkInterfaces': [{
            'subnetwork': context.properties['control_subnet']
        }],
        'serviceAccounts': [{
            'email': context.properties['service_account_email'],
            'scopes': ['https://www.googleapis.com/auth/cloud-platform']
        }],
        'tags': {
            'items': [
                context.properties['infra_id'] + '-master',
            ]
        },
        'zone': context.properties['zones'][0]
    }
}, {
    'name': context.properties['infra_id'] + '-master-1',
    'type': 'compute.v1.instance',
    'properties': {
        'disks': [{
            'autoDelete': True,
            'boot': True,
            'initializeParams': {
                'diskSizeGb': context.properties['root_volume_size'],
                'diskType': 'zones/' + context.properties['zones'][1] + '/diskTypes/pd-ssd',
                'sourceImage': context.properties['image']
            }
        }],
        'machineType': 'zones/' + context.properties['zones'][1] + '/machineTypes/' +
context.properties['machine_type'],
        'metadata': {
            'items': [{
                'key': 'user-data',
                'value': context.properties['ignition']
            }]
        },
        'networkInterfaces': [{
            'subnetwork': context.properties['control_subnet']
        }],
        'serviceAccounts': [{
            'email': context.properties['service_account_email'],
            'scopes': ['https://www.googleapis.com/auth/cloud-platform']
        }],
        'tags': {
            'items': [
                context.properties['infra_id'] + '-master',
            ]
```

```
            },
            'zone': context.properties['zones'][1]
        }
    }, {
        'name': context.properties['infra_id'] + '-master-2',
        'type': 'compute.v1.instance',
        'properties': {
            'disks': [{
                'autoDelete': True,
                'boot': True,
                'initializeParams': {
                    'diskSizeGb': context.properties['root_volume_size'],
                    'diskType': 'zones/' + context.properties['zones'][2] + '/diskTypes/pd-ssd',
                    'sourceImage': context.properties['image']
                }
            }],
            'machineType': 'zones/' + context.properties['zones'][2] + '/machineTypes/' +
context.properties['machine_type'],
            'metadata': {
                'items': [{
                    'key': 'user-data',
                    'value': context.properties['ignition']
                }]
            },
            'networkInterfaces': [{
                'subnetwork': context.properties['control_subnet']
            }],
            'serviceAccounts': [{
                'email': context.properties['service_account_email'],
                'scopes': ['https://www.googleapis.com/auth/cloud-platform']
            }],
            'tags': {
                'items': [
                    context.properties['infra_id'] + '-master',
                ]
            },
            'zone': context.properties['zones'][2]
        }
    }]

    return {'resources': resources}
```

8.10.17. Wait for bootstrap completion and remove bootstrap resources in GCP

After you create all of the required infrastructure in Google Cloud Platform (GCP), wait for the bootstrap process to complete on the machines that you provisioned by using the Ignition config files that you generated with the installation program.

Prerequisites

- Configure a GCP account.
- Generate the Ignition config files for your cluster.

- Create and configure a VPC and associated subnets in GCP.
- Create and configure networking and load balancers in GCP.
- Create control plane and compute roles.
- Create the bootstrap machine.
- Create the control plane machines.

Procedure

1. Change to the directory that contains the installation program and run the following command:

```
$ ./openshift-install wait-for bootstrap-complete --dir <installation_directory> \ 1
    --log-level info 2
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

If the command exits without a **FATAL** warning, your production control plane has initialized.

2. Delete the bootstrap resources:

```
$ gcloud compute backend-services remove-backend ${INFRA_ID}-api-internal-backend-
service --region=${REGION} --instance-group=${INFRA_ID}-bootstrap-ig --instance-group-
zone=${ZONE_0}
```

```
$ gsutil rm gs://${INFRA_ID}-bootstrap-ignition/bootstrap.ign
```

```
$ gsutil rb gs://${INFRA_ID}-bootstrap-ignition
```

```
$ gcloud deployment-manager deployments delete ${INFRA_ID}-bootstrap
```

8.10.18. Creating additional worker machines in GCP

You can create worker machines in Google Cloud Platform (GCP) for your cluster to use by launching individual instances discretely or by automated processes outside the cluster, such as auto scaling groups. You can also take advantage of the built-in cluster scaling mechanisms and the machine API in OpenShift Container Platform.

In this example, you manually launch one instance by using the Deployment Manager template. Additional instances can be launched by including additional resources of type **06_worker.py** in the file.

NOTE

If you do not use the provided Deployment Manager template to create your worker machines, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

Prerequisites

- Configure a GCP account.
- Generate the Ignition config files for your cluster.
- Create and configure a VPC and associated subnets in GCP.
- Create and configure networking and load balancers in GCP.
- Create control plane and compute roles.
- Create the bootstrap machine.
- Create the control plane machines.

Procedure

1. Copy the template from the **Deployment Manager template for worker machines** section of this topic and save it as **06_worker.py** on your computer. This template describes the worker machines that your cluster requires.
2. Export the variables that the resource definition uses.
   a. Export the subnet that hosts the compute machines:

      ```
      $ export COMPUTE_SUBNET=(`gcloud compute networks subnets describe
      ${INFRA_ID}-worker-subnet --region=${REGION} --format json | jq -r .selfLink`)
      ```

   b. Export the email address for your service account:

      ```
      $ export WORKER_SERVICE_ACCOUNT=(`gcloud iam service-accounts list --filter
      "email~^${INFRA_ID}-w@${PROJECT_NAME}." --format json | jq -r '.[0].email'`)
      ```

   c. Export the location of the compute machine Ignition config file:

      ```
      $ export WORKER_IGNITION=`cat <installation_directory>/worker.ign`
      ```

3. Create a **06_worker.yaml** resource definition file:

   ```
   $ cat <<EOF >06_worker.yaml
   imports:
   - path: 06_worker.py

   resources:
   - name: 'worker-0' (1)
     type: 06_worker.py
     properties:
       infra_id: '${INFRA_ID}' (2)
       zone: '${ZONE_0}' (3)
       compute_subnet: '${COMPUTE_SUBNET}' (4)
       image: '${CLUSTER_IMAGE}' (5)
       machine_type: 'n1-standard-4' (6)
       root_volume_size: '128'
   ```

```
    service_account_email: '${WORKER_SERVICE_ACCOUNT}' 7
    ignition: '${WORKER_IGNITION}' 8
- name: 'worker-1'
  type: 06_worker.py
  properties:
    infra_id: '${INFRA_ID}' 9
    zone: '${ZONE_1}' 10
    compute_subnet: '${COMPUTE_SUBNET}' 11
    image: '${CLUSTER_IMAGE}' 12
    machine_type: 'n1-standard-4' 13
    root_volume_size: '128'
    service_account_email: '${WORKER_SERVICE_ACCOUNT}' 14
    ignition: '${WORKER_IGNITION}' 15
EOF
```

1. **name** is the name of the worker machine, for example **worker-0**.
2. 9 **infra_id** is the **INFRA_ID** infrastructure name from the extraction step.
3. 10 **zone** is the zone to deploy the worker machine into, for example **us-central1-a**.
4. 11 **compute_subnet** is the **selfLink** URL to the compute subnet.
5. 12 **image** is the **selfLink** URL to the RHCOS image. [1]
6. 13 **machine_type** is the machine type of the instance, for example **n1-standard-4**.
7. 14 **service_account_email** is the email address for the worker service account that you created.
8. 15 **ignition** is the contents of the **worker.ign** file.

4. Optional: If you want to launch additional instances, include additional resources of type **06_worker.py** in your **06_worker.yaml** resource definition file.
5. Create the deployment by using the **gcloud** CLI:

```
$ gcloud deployment-manager deployments create ${INFRA_ID}-worker --config
06_worker.yaml
```

1. To use a GCP Marketplace image, specify the offer to use:
   - OpenShift Container Platform: **https://www.googleapis.com/compute/v1/projects/redhat-marketplace-public/global/images/redhat-coreos-ocp-48-x86-64-202210040145**
   - OpenShift Platform Plus: **https://www.googleapis.com/compute/v1/projects/redhat-marketplace-public/global/images/redhat-coreos-opp-48-x86-64-202206140145**
   - OpenShift Kubernetes Engine: **https://www.googleapis.com/compute/v1/projects/redhat-marketplace-public/global/images/redhat-coreos-oke-48-x86-64-202206140145**

8.10.18.1. Deployment Manager template for worker machines

You can use the following Deployment Manager template to deploy the worker machines that you need for your OpenShift Container Platform cluster:

Example 8.57. 06_worker.py Deployment Manager template

```
def GenerateConfig(context):

    resources = [{
        'name': context.properties['infra_id'] + '-' + context.env['name'],
        'type': 'compute.v1.instance',
        'properties': {
            'disks': [{
                'autoDelete': True,
                'boot': True,
                'initializeParams': {
                    'diskSizeGb': context.properties['root_volume_size'],
                    'sourceImage': context.properties['image']
                }
            }],
            'machineType': 'zones/' + context.properties['zone'] + '/machineTypes/' +
context.properties['machine_type'],
            'metadata': {
                'items': [{
                    'key': 'user-data',
                    'value': context.properties['ignition']
                }]
            },
            'networkInterfaces': [{
                'subnetwork': context.properties['compute_subnet']
            }],
            'serviceAccounts': [{
                'email': context.properties['service_account_email'],
                'scopes': ['https://www.googleapis.com/auth/cloud-platform']
            }],
            'tags': {
                'items': [
                    context.properties['infra_id'] + '-worker',
                ]
            },
            'zone': context.properties['zone']
        }
    }]

    return {'resources': resources}
```

8.10.19. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.

IMPORTANT

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.11. Download and install the new version of **oc**.

Installing the OpenShift CLI on Linux

You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the architecture in the **Product Variant** drop-down menu.
3. Select the appropriate version in the **Version** drop-down menu.
4. Click **Download Now** next to the **OpenShift v4.11 Linux Client** entry and save the file.
5. Unpack the archive:

```
$ tar xvf <file>
```

6. Place the **oc** binary in a directory that is on your **PATH**.
   To check your **PATH**, execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.
   To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

Verification

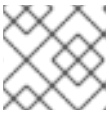
- After you install the OpenShift CLI, it is available using the **oc** command:

```
C:\> oc <command>
```

Installing the OpenShift CLI on macOS
You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 macOS Client** entry and save the file.



NOTE

For macOS arm64, choose the **OpenShift v4.11 macOS arm64 Client** entry.

4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your PATH.
   To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

8.10.20. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

Example output

```
system:admin
```

8.10.21. Approving the certificate signing requests for your machines

When you add machines to a cluster, two pending certificate signing requests (CSRs) are generated for each machine that you added. You must confirm that these CSRs are approved or, if necessary, approve them yourself. The client requests must be approved first, followed by the server requests.

Prerequisites

- You added machines to your cluster.

Procedure

1. Confirm that the cluster recognizes the machines:

```
$ oc get nodes
```

Example output

```
NAME      STATUS   ROLES   AGE  VERSION
master-0  Ready    master  63m  v1.24.0
master-1  Ready    master  63m  v1.24.0
master-2  Ready    master  64m  v1.24.0
```

The output lists all of the machines that you created.

NOTE

The preceding output might not include the compute nodes, also known as worker nodes, until some CSRs are approved.

2. Review the pending CSRs and ensure that you see the client requests with the **Pending** or **Approved** status for each machine that you added to the cluster:

```
$ oc get csr
```

Example output

```
NAME        AGE    REQUESTOR                                                   CONDITION
csr-8b2br   15m    system:serviceaccount:openshift-machine-config-operator:node-
```

```
bootstrapper   Pending
csr-8vnps   15m     system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper   Pending
...
```

In this example, two machines are joining the cluster. You might see more approved CSRs in the list.

3. If the CSRs were not approved, after all of the pending CSRs for the machines you added are in **Pending** status, approve the CSRs for your cluster machines:

NOTE

Because the CSRs rotate automatically, approve your CSRs within an hour of adding the machines to the cluster. If you do not approve them within an hour, the certificates will rotate, and more than two certificates will be present for each node. You must approve all of these certificates. After the client CSR is approved, the Kubelet creates a secondary CSR for the serving certificate, which requires manual approval. Then, subsequent serving certificate renewal requests are automatically approved by the **machine-approver** if the Kubelet requests a new certificate with identical parameters.

NOTE

For clusters running on platforms that are not machine API enabled, such as bare metal and other user-provisioned infrastructure, you must implement a method of automatically approving the kubelet serving certificate requests (CSRs). If a request is not approved, then the **oc exec**, **oc rsh**, and **oc logs** commands cannot succeed, because a serving certificate is required when the API server connects to the kubelet. Any operation that contacts the Kubelet endpoint requires this certificate approval to be in place. The method must watch for new CSRs, confirm that the CSR was submitted by the **node-bootstrapper** service account in the **system:node** or **system:admin** groups, and confirm the identity of the node.

- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

1 **<csr_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{{"\n"}}
{{end}}{{end}}' | xargs --no-run-if-empty oc adm certificate approve
```

NOTE

Some Operators might not become available until some CSRs are approved.

4. Now that your client requests are approved, you must review the server requests for each machine that you added to the cluster:

```
$ oc get csr
```

Example output

```
NAME        AGE     REQUESTOR                                                   CONDITION
csr-bfd72   5m26s   system:node:ip-10-0-50-126.us-east-2.compute.internal        Pending
csr-c57lv   5m26s   system:node:ip-10-0-95-157.us-east-2.compute.internal        Pending
...
```

5. If the remaining CSRs are not approved, and are in the **Pending** status, approve the CSRs for your cluster machines:

   - To approve them individually, run the following command for each valid CSR:

     ```
     $ oc adm certificate approve <csr_name> 1
     ```

     1 **<csr_name>** is the name of a CSR from the list of current CSRs.

   - To approve all pending CSRs, run the following command:

     ```
     $ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{{"\n"}}
     {{end}}{{end}}' | xargs oc adm certificate approve
     ```

6. After all client and server CSRs have been approved, the machines have the **Ready** status. Verify this by running the following command:

   ```
   $ oc get nodes
   ```

   Example output

   ```
   NAME       STATUS   ROLES    AGE  VERSION
   master-0   Ready    master   73m  v1.24.0
   master-1   Ready    master   73m  v1.24.0
   master-2   Ready    master   74m  v1.24.0
   worker-0   Ready    worker   11m  v1.24.0
   worker-1   Ready    worker   11m  v1.24.0
   ```

   NOTE

   It can take a few minutes after approval of the server CSRs for the machines to transition to the **Ready** status.

Additional information

- For more information on CSRs, see Certificate Signing Requests.

8.10.22. Optional: Adding the ingress DNS records

If you removed the DNS zone configuration when creating Kubernetes manifests and generating Ignition

configs, you must manually create DNS records that point at the ingress load balancer. You can create either a wildcard ***.apps.{baseDomain}.** or specific records. You can use A, CNAME, and other records per your requirements.

Prerequisites

- Configure a GCP account.
- Remove the DNS Zone configuration when creating Kubernetes manifests and generating Ignition configs.
- Create and configure a VPC and associated subnets in GCP.
- Create and configure networking and load balancers in GCP.
- Create control plane and compute roles.
- Create the bootstrap machine.
- Create the control plane machines.
- Create the worker machines.

Procedure

1. Wait for the Ingress router to create a load balancer and populate the **EXTERNAL-IP** field:

```
$ oc -n openshift-ingress get service router-default
```

Example output

```
NAME            TYPE           CLUSTER-IP     EXTERNAL-IP     PORT(S)                      AGE
router-default  LoadBalancer   172.30.18.154  35.233.157.184
80:32288/TCP,443:31215/TCP   98
```

2. Add the A record to your zones:
   - To use A records:
     i. Export the variable for the router IP address:

```
$ export ROUTER_IP=`oc -n openshift-ingress get service router-default --no-
headers | awk '{print $4}'`
```

     ii. Add the A record to the private zones:

```
$ if [ -f transaction.yaml ]; then rm transaction.yaml; fi
$ gcloud dns record-sets transaction start --zone ${INFRA_ID}-private-zone
$ gcloud dns record-sets transaction add ${ROUTER_IP} --name
\*.apps.${CLUSTER_NAME}.${BASE_DOMAIN}. --ttl 300 --type A --zone
${INFRA_ID}-private-zone
$ gcloud dns record-sets transaction execute --zone ${INFRA_ID}-private-zone
```

     iii. For an external cluster, also add the A record to the public zones:

```
$ if [ -f transaction.yaml ]; then rm transaction.yaml; fi
$ gcloud dns record-sets transaction start --zone ${BASE_DOMAIN_ZONE_NAME}
$ gcloud dns record-sets transaction add ${ROUTER_IP} --name
\*.apps.${CLUSTER_NAME}.${BASE_DOMAIN}. --ttl 300 --type A --zone
${BASE_DOMAIN_ZONE_NAME}
$ gcloud dns record-sets transaction execute --zone
${BASE_DOMAIN_ZONE_NAME}
```

- To add explicit domains instead of using a wildcard, create entries for each of the cluster's current routes:

```
$ oc get --all-namespaces -o jsonpath='{range .items[*]}{range .status.ingress[*]}{.host}
{"\n"}{end}{end}' routes
```

Example output

```
oauth-openshift.apps.your.cluster.domain.example.com
console-openshift-console.apps.your.cluster.domain.example.com
downloads-openshift-console.apps.your.cluster.domain.example.com
alertmanager-main-openshift-monitoring.apps.your.cluster.domain.example.com
prometheus-k8s-openshift-monitoring.apps.your.cluster.domain.example.com
```

8.10.23. Completing a GCP installation on user-provisioned infrastructure

After you start the OpenShift Container Platform installation on Google Cloud Platform (GCP) user-provisioned infrastructure, you can monitor the cluster events until the cluster is ready.

Prerequisites

- Deploy the bootstrap machine for an OpenShift Container Platform cluster on user-provisioned GCP infrastructure.
- Install the **oc** CLI and log in.

Procedure

1. Complete the cluster installation:

```
$ ./openshift-install --dir <installation_directory> wait-for install-complete 1
```

Example output

```
INFO Waiting up to 30m0s for the cluster to initialize...
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

2. Observe the running state of your cluster.

   a. Run the following command to view the current cluster version and status:

   ```
   $ oc get clusterversion
   ```

   Example output

   ```
   NAME      VERSION   AVAILABLE   PROGRESSING   SINCE   STATUS
   version             False       True          24m     Working towards 4.5.4: 99% complete
   ```

   b. Run the following command to view the Operators managed on the control plane by the Cluster Version Operator (CVO):

   ```
   $ oc get clusteroperators
   ```

   Example output

   ```
   NAME                                       VERSION   AVAILABLE   PROGRESSING   DEGRADED
   SINCE
   authentication                             4.5.4     True        False         False      7m56s
   cloud-credential                           4.5.4     True        False         False      31m
   cluster-autoscaler                         4.5.4     True        False         False      16m
   console                                    4.5.4     True        False         False      10m
   csi-snapshot-controller                    4.5.4     True        False         False      16m
   dns                                        4.5.4     True        False         False      22m
   etcd                                       4.5.4     False       False         False      25s
   image-registry                             4.5.4     True        False         False      16m
   ingress                                    4.5.4     True        False         False      16m
   insights                                   4.5.4     True        False         False      17m
   kube-apiserver                             4.5.4     True        False         False      19m
   kube-controller-manager                    4.5.4     True        False         False      20m
   kube-scheduler                             4.5.4     True        False         False      20m
   kube-storage-version-migrator              4.5.4     True        False         False      16m
   machine-api                                4.5.4     True        False         False      22m
   machine-config                             4.5.4     True        False         False      22m
   marketplace                                4.5.4     True        False         False      16m
   ```

```
monitoring                                 4.5.4     True        False         False      10m
network                                    4.5.4     True        False         False      23m
node-tuning                                4.5.4     True        False         False      23m
openshift-apiserver                        4.5.4     True        False         False      17m
openshift-controller-manager               4.5.4     True        False         False      15m
openshift-samples                          4.5.4     True        False         False      16m
operator-lifecycle-manager                 4.5.4     True        False         False      22m
operator-lifecycle-manager-catalog         4.5.4     True        False         False      22m
operator-lifecycle-manager-packageserver   4.5.4     True        False         False      18m
service-ca                                 4.5.4     True        False         False      23m
service-catalog-apiserver                  4.5.4     True        False         False      23m
service-catalog-controller-manager         4.5.4     True        False         False      23m
storage                                    4.5.4     True        False         False      17m
```

c. Run the following command to view your cluster pods:

```
$ oc get pods --all-namespaces
```

Example output

```
NAMESPACE                                               NAME
READY   STATUS      RESTARTS   AGE
kube-system                                             etcd-member-ip-10-0-3-111.us-east-
2.compute.internal              1/1     Running     0          35m
kube-system                                             etcd-member-ip-10-0-3-239.us-east-
2.compute.internal              1/1     Running     0          37m
kube-system                                             etcd-member-ip-10-0-3-24.us-east-
2.compute.internal              1/1     Running     0          35m
openshift-apiserver-operator                            openshift-apiserver-operator-6d6674f4f4-
h7t2t                           1/1     Running     1          37m
openshift-apiserver                                     apiserver-fm48r
1/1     Running     0          30m
openshift-apiserver                                     apiserver-fxkvv
1/1     Running     0          29m
openshift-apiserver                                     apiserver-q85nm
1/1     Running     0          29m
...
openshift-service-ca-operator                           openshift-service-ca-operator-66ff6dc6cd-
9r257                           1/1     Running     0          37m
openshift-service-ca                                    apiservice-cabundle-injector-695b6bcbc-cl5hm
1/1     Running     0          35m
openshift-service-ca                                    configmap-cabundle-injector-8498544d7-
25qn6                           1/1     Running     0          35m
openshift-service-ca                                    service-serving-cert-signer-6445fc9c6-wqdqn
1/1     Running     0          35m
openshift-service-catalog-apiserver-operator            openshift-service-catalog-apiserver-
operator-549f44668b-b5q2w       1/1     Running     0          32m
openshift-service-catalog-controller-manager-operator   openshift-service-catalog-
controller-manager-operator-b78cr2lnm   1/1     Running     0          31m
```

When the current cluster version is **AVAILABLE**, the installation is complete.

8.10.24. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.11, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to OpenShift Cluster Manager Hybrid Cloud Console.

After you confirm that your OpenShift Cluster Manager Hybrid Cloud Console inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, use subscription watch to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

Additional resources

- See About remote health monitoring for more information about the Telemetry service

8.10.25. Next steps

- Customize your cluster.
- If necessary, you can opt out of remote health reporting .
- Configure Global Access for an Ingress Controller on GCP .

8.11. INSTALLING A CLUSTER INTO A SHARED VPC ON GCP USING DEPLOYMENT MANAGER TEMPLATES

In OpenShift Container Platform version 4.11, you can install a cluster into a shared Virtual Private Cloud (VPC) on Google Cloud Platform (GCP) that uses infrastructure that you provide. In this context, a cluster installed into a shared VPC is a cluster that is configured to use a VPC from a project different from where the cluster is being deployed.

A shared VPC enables an organization to connect resources from multiple projects to a common VPC network. You can communicate within the organization securely and efficiently by using internal IPs from that network. For more information about shared VPC, see Shared VPC overview in the GCP documentation.

The steps for performing a user-provided infrastructure installation into a shared VPC are outlined here. Several Deployment Manager templates are provided to assist in completing these steps or to help model your own. You are also free to create the required resources through other methods.

IMPORTANT

The steps for performing a user-provisioned infrastructure installation are provided as an example only. Installing a cluster with infrastructure you provide requires knowledge of the cloud provider and the installation process of OpenShift Container Platform. Several Deployment Manager templates are provided to assist in completing these steps or to help model your own. You are also free to create the required resources through other methods; the templates are just an example.

8.11.1. Prerequisites

- You reviewed details about the OpenShift Container Platform installation and update processes.

- You read the documentation on selecting a cluster installation method and preparing it for users.
- If you use a firewall and plan to use the Telemetry service, you configured the firewall to allow the sites that your cluster requires access to.
- If the cloud identity and access management (IAM) APIs are not accessible in your environment, or if you do not want to store an administrator-level credential secret in the **kube-system** namespace, you can manually create and maintain IAM credentials.

NOTE

Be sure to also review this site list if you are configuring a proxy.

8.11.2. Certificate signing requests management

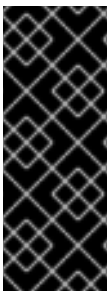
Because your cluster has limited access to automatic machine management when you use infrastructure that you provision, you must provide a mechanism for approving cluster certificate signing requests (CSRs) after installation. The **kube-controller-manager** only approves the kubelet client CSRs. The **machine-approver** cannot guarantee the validity of a serving certificate that is requested by using kubelet credentials because it cannot confirm that the correct machine issued the request. You must determine and implement a method of verifying the validity of the kubelet serving certificate requests and approving them.

8.11.3. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.11, you require access to the internet to install your cluster.

You must have internet access to:

- Access OpenShift Cluster Manager Hybrid Cloud Console to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access Quay.io to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.



IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

8.11.4. Configuring the GCP project that hosts your cluster

Before you can install OpenShift Container Platform, you must configure a Google Cloud Platform (GCP) project to host it.

8.11.4.1. Creating a GCP project

To install OpenShift Container Platform, you must create a project in your Google Cloud Platform (GCP) account to host the cluster.

Procedure

- Create a project to host your OpenShift Container Platform cluster. See Creating and Managing Projects in the GCP documentation.

IMPORTANT

Your GCP project must use the Premium Network Service Tier if you are using installer-provisioned infrastructure. The Standard Network Service Tier is not supported for clusters installed using the installation program. The installation program configures internal load balancing for the **api-int.<cluster_name>.<base_domain>** URL; the Premium Tier is required for internal load balancing.

8.11.4.2. Enabling API services in GCP

Your Google Cloud Platform (GCP) project requires access to several API services to complete OpenShift Container Platform installation.

Prerequisites

- You created a project to host your cluster.

Procedure

- Enable the following required API services in the project that hosts your cluster. You may also enable optional API services which are not required for installation. See Enabling services in the GCP documentation.

Table 8.46. Required API services

API service	Console service name
Compute Engine API	**compute.googleapis.com**
Cloud Resource Manager API	**cloudresourcemanager.googleapis.com**
Google DNS API	**dns.googleapis.com**
IAM Service Account Credentials API	**iamcredentials.googleapis.com**
Identity and Access Management (IAM) API	**iam.googleapis.com**
Service Usage API	**serviceusage.googleapis.com**

Table 8.47. Optional API services

API service	Console service name
Cloud Deployment Manager V2 API	**deploymentmanager.googleapis.com**
Google Cloud APIs	**cloudapis.googleapis.com**
Service Management API	**servicemanagement.googleapis.com**
Google Cloud Storage JSON API	**storage-api.googleapis.com**
Cloud Storage	**storage-component.googleapis.com**

8.11.4.3. GCP account limits

The OpenShift Container Platform cluster uses a number of Google Cloud Platform (GCP) components, but the default Quotas do not affect your ability to install a default OpenShift Container Platform cluster.

A default cluster, which contains three compute and three control plane machines, uses the following resources. Note that some resources are required only during the bootstrap process and are removed after the cluster deploys.

Table 8.48. GCP resources used in a default cluster

Service	Component	Location	Total resources required	Resources removed after bootstrap
Service account	IAM	Global	5	0
Firewall rules	Networking	Global	11	1
Forwarding rules	Compute	Global	2	0
Health checks	Compute	Global	2	0
Images	Compute	Global	1	0
Networks	Networking	Global	1	0
Routers	Networking	Global	1	0
Routes	Networking	Global	2	0
Subnetworks	Compute	Global	2	0
Target pools	Networking	Global	2	0

NOTE

If any of the quotas are insufficient during installation, the installation program displays an error that states both which quota was exceeded and the region.

Be sure to consider your actual cluster size, planned cluster growth, and any usage from other clusters that are associated with your account. The CPU, static IP addresses, and persistent disk SSD (storage) quotas are the ones that are most likely to be insufficient.

If you plan to deploy your cluster in one of the following regions, you will exceed the maximum storage quota and are likely to exceed the CPU quota limit:

- **asia-east2**
- **asia-northeast2**
- **asia-south1**
- **australia-southeast1**
- **europe-north1**
- **europe-west2**
- **europe-west3**
- **europe-west6**
- **northamerica-northeast1**
- **southamerica-east1**
- **us-west2**

You can increase resource quotas from the GCP console, but you might need to file a support ticket. Be sure to plan your cluster size early so that you can allow time to resolve the support ticket before you install your OpenShift Container Platform cluster.

8.11.4.4. Creating a service account in GCP

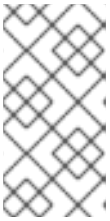
OpenShift Container Platform requires a Google Cloud Platform (GCP) service account that provides authentication and authorization to access data in the Google APIs. If you do not have an existing IAM service account that contains the required roles in your project, you must create one.

Prerequisites

- You created a project to host your cluster.

Procedure

1. Create a service account in the project that you use to host your OpenShift Container Platform cluster. See Creating a service account in the GCP documentation.
2. Grant the service account the appropriate permissions. You can either grant the individual permissions that follow or assign the **Owner** role to it. See Granting roles to a service account for specific resources.



NOTE

While making the service account an owner of the project is the easiest way to gain the required permissions, it means that service account has complete control over the project. You must determine if the risk that comes from offering that power is acceptable.

3. Create the service account key in JSON format. See Creating service account keys in the GCP documentation.
   The service account key is required to create a cluster.

8.11.4.4.1. Required GCP roles

When you attach the **Owner** role to the service account that you create, you grant that service account all permissions, including those that are required to install OpenShift Container Platform. If your organization's security policies require a more restrictive set of permissions, you can create a service account with the following permissions. If you deploy your cluster into an existing virtual private cloud (VPC), the service account does not require certain networking permissions, which are noted in the following lists:

Required roles for the installation program

- Compute Admin
- Security Admin
- Service Account Admin
- Service Account Key Admin
- Service Account User
- Storage Admin

Required roles for creating network resources during installation

- DNS Administrator

Required roles for user-provisioned GCP infrastructure

- Deployment Manager Editor

The roles are applied to the service accounts that the control plane and compute machines use:

Table 8.49. GCP service account permissions

Account	Roles
Control Plane	**roles/compute.instanceAdmin**
	roles/compute.networkAdmin
	roles/compute.securityAdmin

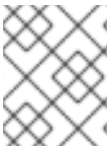
Account	Roles
	roles/storage.admin
	roles/iam.serviceAccountUser
Compute	**roles/compute.viewer**
	roles/storage.admin

8.11.4.5. Supported GCP regions

You can deploy an OpenShift Container Platform cluster to the following Google Cloud Platform (GCP) regions:

- **asia-east1** (Changhua County, Taiwan)
- **asia-east2** (Hong Kong)
- **asia-northeast1** (Tokyo, Japan)
- **asia-northeast2** (Osaka, Japan)
- **asia-northeast3** (Seoul, South Korea)
- **asia-south1** (Mumbai, India)
- **asia-south2** (Delhi, India)
- **asia-southeast1** (Jurong West, Singapore)
- **asia-southeast2** (Jakarta, Indonesia)
- **australia-southeast1** (Sydney, Australia)
- **australia-southeast2** (Melbourne, Australia)
- **europe-central2** (Warsaw, Poland)
- **europe-north1** (Hamina, Finland)
- **europe-southwest1** (Madrid, Spain)
- **europe-west1** (St. Ghislain, Belgium)
- **europe-west2** (London, England, UK)
- **europe-west3** (Frankfurt, Germany)
- **europe-west4** (Eemshaven, Netherlands)
- **europe-west6** (Zürich, Switzerland)
- **europe-west8** (Milan, Italy)

- **europe-west9** (Paris, France)
- **europe-west12** (Turin, Italy)
- **northamerica-northeast1** (Montréal, Québec, Canada)
- **northamerica-northeast2** (Toronto, Ontario, Canada)
- **southamerica-east1** (São Paulo, Brazil)
- **southamerica-west1** (Santiago, Chile)
- **us-central1** (Council Bluffs, Iowa, USA)
- **us-east1** (Moncks Corner, South Carolina, USA)
- **us-east4** (Ashburn, Northern Virginia, USA)
- **us-east5** (Columbus, Ohio)
- **us-south1** (Dallas, Texas)
- **us-west1** (The Dalles, Oregon, USA)
- **us-west2** (Los Angeles, California, USA)
- **us-west3** (Salt Lake City, Utah, USA)
- **us-west4** (Las Vegas, Nevada, USA)



NOTE

To determine which machine type instances are available by region and zone, see the Google documentation.

8.11.4.6. Installing and configuring CLI tools for GCP

To install OpenShift Container Platform on Google Cloud Platform (GCP) using user-provisioned infrastructure, you must install and configure the CLI tools for GCP.

Prerequisites

- You created a project to host your cluster.
- You created a service account and granted it the required permissions.

Procedure

1. Install the following binaries in **$PATH**:
   - **gcloud**
   - **gsutil**

   See Install the latest Cloud SDK version in the GCP documentation.
2. Authenticate using the **gcloud** tool with your configured service account.

See Authorizing with a service account in the GCP documentation.

8.11.5. Requirements for a cluster with user-provisioned infrastructure

For a cluster that contains user-provisioned infrastructure, you must deploy all of the required machines.

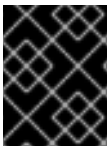
This section describes the requirements for deploying OpenShift Container Platform on user-provisioned infrastructure.

8.11.5.1. Required machines for cluster installation

The smallest OpenShift Container Platform clusters require the following hosts:

Table 8.50. Minimum required hosts

Hosts	Description
One temporary bootstrap machine	The cluster requires the bootstrap machine to deploy the OpenShift Container Platform cluster on the three control plane machines. You can remove the bootstrap machine after you install the cluster.
Three control plane machines	The control plane machines run the Kubernetes and OpenShift Container Platform services that form the control plane.
At least two compute machines, which are also known as worker machines.	The workloads requested by OpenShift Container Platform users run on the compute machines.



IMPORTANT

To maintain high availability of your cluster, use separate physical hosts for these cluster machines.

The bootstrap and control plane machines must use Red Hat Enterprise Linux CoreOS (RHCOS) as the operating system. However, the compute machines can choose between Red Hat Enterprise Linux CoreOS (RHCOS), Red Hat Enterprise Linux (RHEL) 8.6 and later.

Note that RHCOS is based on Red Hat Enterprise Linux (RHEL) 8 and inherits all of its hardware certifications and requirements. See Red Hat Enterprise Linux technology capabilities and limits .

8.11.5.2. Minimum resource requirements for cluster installation

Each cluster machine must meet the following minimum requirements:

Table 8.51. Minimum resource requirements

Machine	Operating System	vCPU [1]	Virtual RAM	Storage	IOPS [2]
Bootstrap	RHCOS	4	16 GB	100 GB	300

Machine	Operating System	vCPU [1]	Virtual RAM	Storage	IOPS [2]
Control plane	RHCOS	4	16 GB	100 GB	300
Compute	RHCOS, RHEL 8.6 and later [3]	2	8 GB	100 GB	300

1. One vCPU is equivalent to one physical core when simultaneous multithreading (SMT), or hyperthreading, is not enabled. When enabled, use the following formula to calculate the corresponding ratio: (threads per core × cores) × sockets = vCPUs.

2. OpenShift Container Platform and Kubernetes are sensitive to disk performance, and faster storage is recommended, particularly for etcd on the control plane nodes which require a 10 ms p99 fsync duration. Note that on many cloud platforms, storage size and IOPS scale together, so you might need to over-allocate storage volume to obtain sufficient performance.

3. As with all user-provisioned installations, if you choose to use RHEL compute machines in your cluster, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks. Use of RHEL 7 compute machines is deprecated and has been removed in OpenShift Container Platform 4.10 and later.

If an instance type for your platform meets the minimum requirements for cluster machines, it is supported to use in OpenShift Container Platform.

Additional resources

- Optimizing storage

8.11.5.3. Tested instance types for GCP

The following Google Cloud Platform instance types have been tested with OpenShift Container Platform.

Example 8.58. Machine series

- **C2**
- **C2D**
- **C3**
- **E2**
- **M1**
- **N1**
- **N2**
- **N2D**

- **Tau T2D**

8.11.5.4. Using custom machine types

Using a custom machine type to install a OpenShift Container Platform cluster is supported.

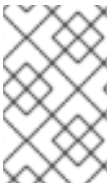
Consider the following when using a custom machine type:

- Similar to predefined instance types, custom machine types must meet the minimum resource requirements for control plane and compute machines. For more information, see "Minimum resource requirements for cluster installation".
- The name of the custom machine type must adhere to the following syntax: **custom-<number_of_cpus>-<amount_of_memory_in_mb>**

  For example, **custom-6-20480**.

8.11.6. Configuring the GCP project that hosts your shared VPC network

If you use a shared Virtual Private Cloud (VPC) to host your OpenShift Container Platform cluster in Google Cloud Platform (GCP), you must configure the project that hosts it.

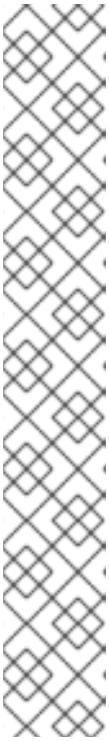


NOTE

If you already have a project that hosts the shared VPC network, review this section to ensure that the project meets all of the requirements to install an OpenShift Container Platform cluster.

Procedure

1. Create a project to host the shared VPC for your OpenShift Container Platform cluster. See Creating and Managing Projects in the GCP documentation.
2. Create a service account in the project that hosts your shared VPC. See Creating a service account in the GCP documentation.
3. Grant the service account the appropriate permissions. You can either grant the individual permissions that follow or assign the **Owner** role to it. See Granting roles to a service account for specific resources.



NOTE

While making the service account an owner of the project is the easiest way to gain the required permissions, it means that service account has complete control over the project. You must determine if the risk that comes from offering that power is acceptable.

The service account for the project that hosts the shared VPC network requires the following roles:

- Compute Network User
- Compute Security Admin
- Deployment Manager Editor
- DNS Administrator
- Security Admin
- Network Management Admin

8.11.6.1. Configuring DNS for GCP

To install OpenShift Container Platform, the Google Cloud Platform (GCP) account you use must have a dedicated public hosted zone in the project that hosts the shared VPC that you install the cluster into. This zone must be authoritative for the domain. The DNS service provides cluster DNS resolution and name lookup for external connections to the cluster.

Procedure

1. Identify your domain, or subdomain, and registrar. You can transfer an existing domain and registrar or obtain a new one through GCP or another source.

NOTE

If you purchase a new domain, it can take time for the relevant DNS changes to propagate. For more information about purchasing domains through Google, see Google Domains.

2. Create a public hosted zone for your domain or subdomain in your GCP project. See Creating public zones in the GCP documentation.
   Use an appropriate root domain, such as **openshiftcorp.com**, or subdomain, such as **clusters.openshiftcorp.com**.

3. Extract the new authoritative name servers from the hosted zone records. See Look up your Cloud DNS name servers in the GCP documentation.
   You typically have four name servers.

4. Update the registrar records for the name servers that your domain uses. For example, if you registered your domain to Google Domains, see the following topic in the Google Domains Help: How to switch to custom name servers .

5. If you migrated your root domain to Google Cloud DNS, migrate your DNS records. See Migrating to Cloud DNS in the GCP documentation.

6. If you use a subdomain, follow your company's procedures to add its delegation records to the parent domain. This process might include a request to your company's IT department or the division that controls the root domain and DNS services for your company.

8.11.6.2. Creating a VPC in GCP

You must create a VPC in Google Cloud Platform (GCP) for your OpenShift Container Platform cluster to use. You can customize the VPC to meet your requirements. One way to create the VPC is to modify the provided Deployment Manager template.

NOTE

If you do not use the provided Deployment Manager template to create your GCP infrastructure, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

Prerequisites

- Configure a GCP account.

Procedure

1. Copy the template from the **Deployment Manager template for the VPC**section of this topic and save it as **01_vpc.py** on your computer. This template describes the VPC that your cluster requires.
2. Export the following variables required by the resource definition:
   a. Export the control plane CIDR:

      ```
      $ export MASTER_SUBNET_CIDR='10.0.0.0/17'
      ```

   b. Export the compute CIDR:

      ```
      $ export WORKER_SUBNET_CIDR='10.0.128.0/17'
      ```

   c. Export the region to deploy the VPC network and cluster to:

      ```
      $ export REGION='<region>'
      ```

3. Export the variable for the ID of the project that hosts the shared VPC:

   ```
   $ export HOST_PROJECT=<host_project>
   ```

4. Export the variable for the email of the service account that belongs to host project:

   ```
   $ export HOST_PROJECT_ACCOUNT=<host_service_account_email>
   ```

5. Create a **01_vpc.yaml** resource definition file:

   ```
   $ cat <<EOF >01_vpc.yaml
   imports:
   ```

```
- path: 01_vpc.py

resources:
- name: cluster-vpc
  type: 01_vpc.py
  properties:
    infra_id: '<prefix>' 1
    region: '${REGION}' 2
    master_subnet_cidr: '${MASTER_SUBNET_CIDR}' 3
    worker_subnet_cidr: '${WORKER_SUBNET_CIDR}' 4
EOF
```

1. **infra_id** is the prefix of the network name.
2. **region** is the region to deploy the cluster into, for example **us-central1**.
3. **master_subnet_cidr** is the CIDR for the master subnet, for example **10.0.0.0/17**.
4. **worker_subnet_cidr** is the CIDR for the worker subnet, for example **10.0.128.0/17**.

6. Create the deployment by using the **gcloud** CLI:

```
$ gcloud deployment-manager deployments create <vpc_deployment_name> --config
01_vpc.yaml --project ${HOST_PROJECT} --account ${HOST_PROJECT_ACCOUNT} 1
```

1. For **<vpc_deployment_name>**, specify the name of the VPC to deploy.

7. Export the VPC variable that other components require:
   a. Export the name of the host project network:

```
$ export HOST_PROJECT_NETWORK=<vpc_network>
```

   b. Export the name of the host project control plane subnet:

```
$ export HOST_PROJECT_CONTROL_SUBNET=<control_plane_subnet>
```

   c. Export the name of the host project compute subnet:

```
$ export HOST_PROJECT_COMPUTE_SUBNET=<compute_subnet>
```

8. Set up the shared VPC. See Setting up Shared VPC in the GCP documentation.

8.11.6.2.1. Deployment Manager template for the VPC

You can use the following Deployment Manager template to deploy the VPC that you need for your OpenShift Container Platform cluster:

Example 8.59. 01_vpc.py Deployment Manager template

```
def GenerateConfig(context):
```

```
    resources = [{
        'name': context.properties['infra_id'] + '-network',
        'type': 'compute.v1.network',
        'properties': {
            'region': context.properties['region'],
            'autoCreateSubnetworks': False
        }
    }, {
        'name': context.properties['infra_id'] + '-master-subnet',
        'type': 'compute.v1.subnetwork',
        'properties': {
            'region': context.properties['region'],
            'network': '$(ref.' + context.properties['infra_id'] + '-network.selfLink)',
            'ipCidrRange': context.properties['master_subnet_cidr']
        }
    }, {
        'name': context.properties['infra_id'] + '-worker-subnet',
        'type': 'compute.v1.subnetwork',
        'properties': {
            'region': context.properties['region'],
            'network': '$(ref.' + context.properties['infra_id'] + '-network.selfLink)',
            'ipCidrRange': context.properties['worker_subnet_cidr']
        }
    }, {
        'name': context.properties['infra_id'] + '-router',
        'type': 'compute.v1.router',
        'properties': {
            'region': context.properties['region'],
            'network': '$(ref.' + context.properties['infra_id'] + '-network.selfLink)',
            'nats': [{
                'name': context.properties['infra_id'] + '-nat-master',
                'natIpAllocateOption': 'AUTO_ONLY',
                'minPortsPerVm': 7168,
                'sourceSubnetworkIpRangesToNat': 'LIST_OF_SUBNETWORKS',
                'subnetworks': [{
                    'name': '$(ref.' + context.properties['infra_id'] + '-master-subnet.selfLink)',
                    'sourceIpRangesToNat': ['ALL_IP_RANGES']
                }]
            }, {
                'name': context.properties['infra_id'] + '-nat-worker',
                'natIpAllocateOption': 'AUTO_ONLY',
                'minPortsPerVm': 512,
                'sourceSubnetworkIpRangesToNat': 'LIST_OF_SUBNETWORKS',
                'subnetworks': [{
                    'name': '$(ref.' + context.properties['infra_id'] + '-worker-subnet.selfLink)',
                    'sourceIpRangesToNat': ['ALL_IP_RANGES']
                }]
            }]
        }
    }]

    return {'resources': resources}
```

8.11.7. Creating the installation files for GCP

To install OpenShift Container Platform on Google Cloud Platform (GCP) using user-provisioned infrastructure, you must generate the files that the installation program needs to deploy your cluster and modify them so that the cluster creates only the machines that it will use. You generate and customize the **install-config.yaml** file, Kubernetes manifests, and Ignition config files. You also have the option to first set up a separate **var** partition during the preparation phases of installation.

8.11.7.1. Manually creating the installation configuration file

Prerequisites

- You have an SSH public key on your local machine to provide to the installation program. The key will be used for SSH authentication onto your cluster nodes for debugging and disaster recovery.
- You have obtained the OpenShift Container Platform installation program and the pull secret for your cluster.

Procedure

1. Create an installation directory to store your required installation assets in:

```
$ mkdir <installation_directory>
```

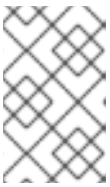
IMPORTANT

You must create a directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

2. Customize the sample **install-config.yaml** file template that is provided and save it in the **<installation_directory>**.

NOTE

You must name this configuration file **install-config.yaml**.



NOTE

For some platform types, you can alternatively run **./openshift-install create install-config --dir <installation_directory>** to generate an **install-config.yaml** file. You can provide details about your cluster configuration at the prompts.

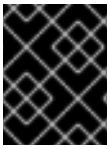
3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.

IMPORTANT

The **install-config.yaml** file is consumed during the next step of the installation process. You must back it up now.

8.11.7.2. Sample customized install-config.yaml file for GCP

You can customize the **install-config.yaml** file to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.



IMPORTANT

This sample YAML file is provided for reference only. You must obtain your **install-config.yaml** file by using the installation program and modify it.

```
apiVersion: v1
baseDomain: example.com (1)
controlPlane: (2)
  hyperthreading: Enabled (3) (4)
  name: master
  platform:
    gcp:
      type: n2-standard-4
      zones:
      - us-central1-a
      - us-central1-c
  replicas: 3
compute: (5)
- hyperthreading: Enabled (6)
  name: worker
  platform:
    gcp:
      type: n2-standard-4
      zones:
      - us-central1-a
      - us-central1-c
  replicas: 0
metadata:
  name: test-cluster
networking:
  clusterNetwork:
  - cidr: 10.128.0.0/14
    hostPrefix: 23
  machineNetwork:
  - cidr: 10.0.0.0/16
  networkType: OpenShiftSDN
  serviceNetwork:
  - 172.30.0.0/16
platform:
  gcp:
    projectID: openshift-production (7)
    region: us-central1 (8)
pullSecret: '{"auths": ...}'
fips: false (9)
sshKey: ssh-ed25519 AAAA... (10)
publish: Internal (11)
```

(1) Specify the public DNS on the host project.

2 5 If you do not provide these parameters and values, the installation program provides the default value.

3 6 The **controlPlane** section is a single mapping, but the compute section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, **-**, and the first line of the **controlPlane** section must not. Although both sections currently define a single machine pool, it is possible that future versions of OpenShift Container Platform will support defining multiple compute pools during installation. Only one control plane pool is used.

4 Whether to enable or disable simultaneous multithreading, or **hyperthreading**. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores. You can disable it by setting the parameter value to **Disabled**. If you disable simultaneous multithreading in some cluster machines, you must disable it in all cluster machines.

IMPORTANT

If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance. Use larger machine types, such as **n1-standard-8**, for your machines if you disable simultaneous multithreading.

7 Specify the main project where the VM instances reside.

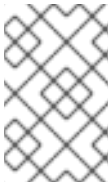
8 Specify the region that your VPC network is in.

9 Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.

IMPORTANT

The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.

10 You can optionally provide the **sshKey** value that you use to access the machines in your cluster.



NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

11 How to publish the user-facing endpoints of your cluster. Set **publish** to **Internal** to deploy a private cluster, which cannot be accessed from the internet. The default value is **External**. To use a shared VPC in a cluster that uses infrastructure that you provision, you must set **publish** to **Internal**. The installation program will no longer be able to access the public DNS zone for the base domain in the host project.

8.11.7.3. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.

NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
```

1. A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
2. A proxy URL to use for creating HTTPS connections outside the cluster.
3. A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use * to bypass the proxy for all destinations.
4. If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace that contains one or more additional CA certificates that are required for proxying HTTPS connections. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges these contents with the Red Hat Enterprise Linux CoreOS (RHCOS) trust bundle, and this config map is referenced in the **trustedCA** field of the **Proxy** object. The **additionalTrustBundle** field is required unless

the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.

NOTE

The installation program does not support the proxy **readinessEndpoints** field.

NOTE

If the installer times out, restart and then complete the deployment by using the **wait-for** command of the installer. For example:

```
$ ./openshift-install wait-for install-complete --log-level debug
```

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.

NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

8.11.7.4. Creating the Kubernetes manifest and Ignition config files

Because you must modify some cluster definition files and manually start the cluster machines, you must generate the Kubernetes manifest and Ignition config files that the cluster needs to configure the machines.

The installation configuration file transforms into the Kubernetes manifests. The manifests wrap into the Ignition configuration files, which are later used to configure the cluster machines.

IMPORTANT

- The Ignition config files that the OpenShift Container Platform installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

Prerequisites

- You obtained the OpenShift Container Platform installation program.

- You created the **install-config.yaml** installation configuration file.

Procedure

1. Change to the directory that contains the OpenShift Container Platform installation program and generate the Kubernetes manifests for the cluster:

```
$ ./openshift-install create manifests --dir <installation_directory> 1
```

1 For **<installation_directory>**, specify the installation directory that contains the **install-config.yaml** file you created.

2. Remove the Kubernetes manifest files that define the control plane machines:

```
$ rm -f <installation_directory>/openshift/99_openshift-cluster-api_master-machines-*.yaml
```

By removing these files, you prevent the cluster from automatically generating control plane machines.

3. Remove the Kubernetes manifest files that define the worker machines:

```
$ rm -f <installation_directory>/openshift/99_openshift-cluster-api_worker-machineset-*.yaml
```

Because you create and manage the worker machines yourself, you do not need to initialize these machines.

4. Check that the **mastersSchedulable** parameter in the **<installation_directory>/manifests/cluster-scheduler-02-config.yml** Kubernetes manifest file is set to **false**. This setting prevents pods from being scheduled on the control plane machines:

   a. Open the **<installation_directory>/manifests/cluster-scheduler-02-config.yml** file.

   b. Locate the **mastersSchedulable** parameter and ensure that it is set to **false**.

   c. Save and exit the file.

5. Remove the **privateZone** sections from the **<installation_directory>/manifests/cluster-dns-02-config.yml** DNS configuration file:

```
apiVersion: config.openshift.io/v1
kind: DNS
metadata:
  creationTimestamp: null
  name: cluster
spec:
  baseDomain: example.openshift.com
  privateZone: 1
    id: mycluster-100419-private-zone
status: {}
```

1 Remove this section completely.

6. Configure the cloud provider for your VPC.

   a. Open the **<installation_directory>/manifests/cloud-provider-config.yaml** file.

   b. Add the **network-project-id** parameter and set its value to the ID of project that hosts the shared VPC network.

   c. Add the **network-name** parameter and set its value to the name of the shared VPC network that hosts the OpenShift Container Platform cluster.

   d. Replace the value of the **subnetwork-name** parameter with the value of the shared VPC subnet that hosts your compute machines.

   The contents of the **<installation_directory>/manifests/cloud-provider-config.yaml** resemble the following example:

```
config: |+
  [global]
  project-id      = example-project
  regional        = true
  multizone       = true
  node-tags       = opensh-ptzzx-master
  node-tags       = opensh-ptzzx-worker
  node-instance-prefix = opensh-ptzzx
  external-instance-groups-prefix = opensh-ptzzx
  network-project-id = example-shared-vpc
  network-name    = example-network
  subnetwork-name = example-worker-subnet
```

7. If you deploy a cluster that is not on a private network, open the **<installation_directory>/manifests/cluster-ingress-default-ingresscontroller.yaml** file and replace the value of the **scope** parameter with **External**. The contents of the file resemble the following example:

```
apiVersion: operator.openshift.io/v1
kind: IngressController
metadata:
  creationTimestamp: null
  name: default
  namespace: openshift-ingress-operator
spec:
  endpointPublishingStrategy:
    loadBalancer:
      scope: External
    type: LoadBalancerService
status:
  availableReplicas: 0
  domain: ''
  selector: ''
```

8. To create the Ignition configuration files, run the following command from the directory that contains the installation program:

```
$ ./openshift-install create ignition-configs --dir <installation_directory> 1
```

1 For **<installation_directory>**, specify the same installation directory.

Ignition config files are created for the bootstrap, control plane, and compute nodes in the installation directory. The **kubeadmin-password** and **kubeconfig** files are created in the **./<installation_directory>/auth** directory:

```
.
├── auth
│   ├── kubeadmin-password
│   └── kubeconfig
├── bootstrap.ign
├── master.ign
├── metadata.json
└── worker.ign
```

8.11.8. Exporting common variables

8.11.8.1. Extracting the infrastructure name

The Ignition config files contain a unique cluster identifier that you can use to uniquely identify your cluster in Google Cloud Platform (GCP). The infrastructure name is also used to locate the appropriate GCP resources during an OpenShift Container Platform installation. The provided Deployment Manager templates contain references to this infrastructure name, so you must extract it.

Prerequisites

- You obtained the OpenShift Container Platform installation program and the pull secret for your cluster.
- You generated the Ignition config files for your cluster.
- You installed the **jq** package.

Procedure

- To extract and view the infrastructure name from the Ignition config file metadata, run the following command:

```
$ jq -r .infraID <installation_directory>/metadata.json 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

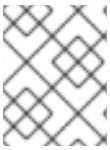
Example output

```
openshift-vw9j6 1
```

1 The output of this command is your cluster name and a random string.

8.11.8.2. Exporting common variables for Deployment Manager templates

You must export a common set of variables that are used with the provided Deployment Manager templates used to assist in completing a user-provided infrastructure install on Google Cloud Platform (GCP).



NOTE

Specific Deployment Manager templates can also require additional exported variables, which are detailed in their related procedures.

Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.
- Generate the Ignition config files for your cluster.
- Install the **jq** package.

Procedure

1. Export the following common variables to be used by the provided Deployment Manager templates:

```
$ export BASE_DOMAIN='<base_domain>' 1
$ export BASE_DOMAIN_ZONE_NAME='<base_domain_zone_name>' 2
$ export NETWORK_CIDR='10.0.0.0/16'

$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 3
$ export CLUSTER_NAME=`jq -r .clusterName <installation_directory>/metadata.json`
$ export INFRA_ID=`jq -r .infraID <installation_directory>/metadata.json`
$ export PROJECT_NAME=`jq -r .gcp.projectID <installation_directory>/metadata.json`
```

1 2 Supply the values for the host project.

3 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

8.11.9. Networking requirements for user-provisioned infrastructure

All the Red Hat Enterprise Linux CoreOS (RHCOS) machines require networking to be configured in **initramfs** during boot to fetch their Ignition config files.

8.11.9.1. Setting the cluster node hostnames through DHCP

On Red Hat Enterprise Linux CoreOS (RHCOS) machines, the hostname is set through NetworkManager. By default, the machines obtain their hostname through DHCP. If the hostname is not provided by DHCP, set statically through kernel arguments, or another method, it is obtained through a reverse DNS lookup. Reverse DNS lookup occurs after the network has been initialized on a node and can take time to resolve. Other system services can start prior to this and detect the hostname as **localhost** or similar. You can avoid this by using DHCP to provide the hostname for each cluster node.

Additionally, setting the hostnames through DHCP can bypass any manual DNS record name configuration errors in environments that have a DNS split-horizon implementation.

8.11.9.2. Network connectivity requirements

You must configure the network connectivity between machines to allow OpenShift Container Platform cluster components to communicate. Each machine must be able to resolve the hostnames of all other machines in the cluster.

This section provides details about the ports that are required.

IMPORTANT

In connected OpenShift Container Platform environments, all nodes are required to have internet access to pull images for platform containers and provide telemetry data to Red Hat.

Table 8.52. Ports used for all-machine to all-machine communications

Protocol	Port	Description
ICMP	N/A	Network reachability tests
TCP	**1936**	Metrics
	9000-**9999**	Host level services, including the node exporter on ports **9100**-**9101** and the Cluster Version Operator on port**9099**.
	10250-**10259**	The default ports that Kubernetes reserves
	10256	openshift-sdn
UDP	**4789**	VXLAN
	6081	Geneve
	9000-**9999**	Host level services, including the node exporter on ports **9100**-**9101**.
	500	IPsec IKE packets
	4500	IPsec NAT-T packets
TCP/UDP	**30000**-**32767**	Kubernetes node port
ESP	N/A	IPsec Encapsulating Security Payload (ESP)

Table 8.53. Ports used for all-machine to control plane communications

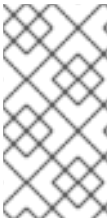
Protocol	Port	Description
TCP	**6443**	Kubernetes API

Table 8.54. Ports used for control plane machine to control plane machine communications

Protocol	Port	Description
TCP	**2379-2380**	etcd server and peer ports

8.11.10. Creating load balancers in GCP

You must configure load balancers in Google Cloud Platform (GCP) for your OpenShift Container Platform cluster to use. One way to create these components is to modify the provided Deployment Manager template.



NOTE

If you do not use the provided Deployment Manager template to create your GCP infrastructure, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

Prerequisites

- Configure a GCP account.
- Generate the Ignition config files for your cluster.
- Create and configure a VPC and associated subnets in GCP.

Procedure

1. Copy the template from the **Deployment Manager template for the internal load balancer** section of this topic and save it as **02_lb_int.py** on your computer. This template describes the internal load balancing objects that your cluster requires.
2. For an external cluster, also copy the template from the **Deployment Manager template for the external load balancer** section of this topic and save it as **02_lb_ext.py** on your computer. This template describes the external load balancing objects that your cluster requires.
3. Export the variables that the deployment template uses:
   a. Export the cluster network location:

```
$ export CLUSTER_NETWORK=(`gcloud compute networks describe
${HOST_PROJECT_NETWORK} --project ${HOST_PROJECT} --account
${HOST_PROJECT_ACCOUNT} --format json | jq -r .selfLink`)
```

   b. Export the control plane subnet location:

```
$ export CONTROL_SUBNET=(`gcloud compute networks subnets describe
${HOST_PROJECT_CONTROL_SUBNET} --region=${REGION} --project
${HOST_PROJECT} --account ${HOST_PROJECT_ACCOUNT} --format json | jq -r
.selfLink`)
```

   c. Export the three zones that the cluster uses:

```
-
```

```
$ export ZONE_0=(`gcloud compute regions describe ${REGION} --format=json | jq -r
.zones[0] | cut -d "/" -f9`)
```

```
$ export ZONE_1=(`gcloud compute regions describe ${REGION} --format=json | jq -r
.zones[1] | cut -d "/" -f9`)
```

```
$ export ZONE_2=(`gcloud compute regions describe ${REGION} --format=json | jq -r
.zones[2] | cut -d "/" -f9`)
```

4. Create a **02_infra.yaml** resource definition file:

```
$ cat <<EOF >02_infra.yaml
imports:
- path: 02_lb_ext.py
- path: 02_lb_int.py (1)
resources:
- name: cluster-lb-ext (2)
  type: 02_lb_ext.py
  properties:
    infra_id: '${INFRA_ID}' (3)
    region: '${REGION}' (4)
- name: cluster-lb-int
  type: 02_lb_int.py
  properties:
    cluster_network: '${CLUSTER_NETWORK}'
    control_subnet: '${CONTROL_SUBNET}' (5)
    infra_id: '${INFRA_ID}'
    region: '${REGION}'
    zones: (6)
    - '${ZONE_0}'
    - '${ZONE_1}'
    - '${ZONE_2}'
EOF
```

(1) (2) Required only when deploying an external cluster.

(3) **infra_id** is the **INFRA_ID** infrastructure name from the extraction step.

(4) **region** is the region to deploy the cluster into, for example **us-central1**.

(5) **control_subnet** is the URI to the control subnet.

(6) **zones** are the zones to deploy the control plane instances into, like **us-east1-b**, **us-east1-c**, and **us-east1-d**.

5. Create the deployment by using the **gcloud** CLI:

```
$ gcloud deployment-manager deployments create ${INFRA_ID}-infra --config 02_infra.yaml
```

6. Export the cluster IP address:

```
$ export CLUSTER_IP=(`gcloud compute addresses describe ${INFRA_ID}-cluster-ip --
region=${REGION} --format json | jq -r .address`)
```

7. For an external cluster, also export the cluster public IP address:

```
$ export CLUSTER_PUBLIC_IP=(`gcloud compute addresses describe ${INFRA_ID}-cluster-
public-ip --region=${REGION} --format json | jq -r .address`)
```

8.11.10.1. Deployment Manager template for the external load balancer

You can use the following Deployment Manager template to deploy the external load balancer that you need for your OpenShift Container Platform cluster:

Example 8.60. 02_lb_ext.py Deployment Manager template

```
def GenerateConfig(context):

    resources = [{
        'name': context.properties['infra_id'] + '-cluster-public-ip',
        'type': 'compute.v1.address',
        'properties': {
            'region': context.properties['region']
        }
    }, {
        # Refer to docs/dev/kube-apiserver-health-check.md on how to correctly setup health check
probe for kube-apiserver
        'name': context.properties['infra_id'] + '-api-http-health-check',
        'type': 'compute.v1.httpHealthCheck',
        'properties': {
            'port': 6080,
            'requestPath': '/readyz'
        }
    }, {
        'name': context.properties['infra_id'] + '-api-target-pool',
        'type': 'compute.v1.targetPool',
        'properties': {
            'region': context.properties['region'],
            'healthChecks': ['$(ref.' + context.properties['infra_id'] + '-api-http-health-check.selfLink)'],
            'instances': []
        }
    }, {
        'name': context.properties['infra_id'] + '-api-forwarding-rule',
        'type': 'compute.v1.forwardingRule',
        'properties': {
            'region': context.properties['region'],
            'IPAddress': '$(ref.' + context.properties['infra_id'] + '-cluster-public-ip.selfLink)',
            'target': '$(ref.' + context.properties['infra_id'] + '-api-target-pool.selfLink)',
            'portRange': '6443'
        }
    }]

    return {'resources': resources}
```

8.11.10.2. Deployment Manager template for the internal load balancer

You can use the following Deployment Manager template to deploy the internal load balancer that you need for your OpenShift Container Platform cluster:

Example 8.61. 02_lb_int.py Deployment Manager template

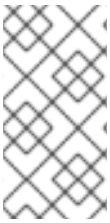
```
def GenerateConfig(context):

    backends = []
    for zone in context.properties['zones']:
        backends.append({
            'group': '$(ref.' + context.properties['infra_id'] + '-master-' + zone + '-ig' + '.selfLink)'
        })

    resources = [{
        'name': context.properties['infra_id'] + '-cluster-ip',
        'type': 'compute.v1.address',
        'properties': {
            'addressType': 'INTERNAL',
            'region': context.properties['region'],
            'subnetwork': context.properties['control_subnet']
        }
    }, {
        # Refer to docs/dev/kube-apiserver-health-check.md on how to correctly setup health check
probe for kube-apiserver
        'name': context.properties['infra_id'] + '-api-internal-health-check',
        'type': 'compute.v1.healthCheck',
        'properties': {
            'httpsHealthCheck': {
                'port': 6443,
                'requestPath': '/readyz'
            },
            'type': "HTTPS"
        }
    }, {
        'name': context.properties['infra_id'] + '-api-internal-backend-service',
        'type': 'compute.v1.regionBackendService',
        'properties': {
            'backends': backends,
            'healthChecks': ['$(ref.' + context.properties['infra_id'] + '-api-internal-health-
check.selfLink)'],
            'loadBalancingScheme': 'INTERNAL',
            'region': context.properties['region'],
            'protocol': 'TCP',
            'timeoutSec': 120
        }
    }, {
        'name': context.properties['infra_id'] + '-api-internal-forwarding-rule',
        'type': 'compute.v1.forwardingRule',
        'properties': {
            'backendService': '$(ref.' + context.properties['infra_id'] + '-api-internal-backend-
service.selfLink)',
            'IPAddress': '$(ref.' + context.properties['infra_id'] + '-cluster-ip.selfLink)',
            'loadBalancingScheme': 'INTERNAL',
            'ports': ['6443','22623'],
```

```
            'region': context.properties['region'],
            'subnetwork': context.properties['control_subnet']
        }
    }]

    for zone in context.properties['zones']:
        resources.append({
            'name': context.properties['infra_id'] + '-master-' + zone + '-ig',
            'type': 'compute.v1.instanceGroup',
            'properties': {
                'namedPorts': [
                    {
                        'name': 'ignition',
                        'port': 22623
                    }, {
                        'name': 'https',
                        'port': 6443
                    }
                ],
                'network': context.properties['cluster_network'],
                'zone': zone
            }
        })

    return {'resources': resources}
```

You will need this template in addition to the **02_lb_ext.py** template when you create an external cluster.

8.11.11. Creating a private DNS zone in GCP

You must configure a private DNS zone in Google Cloud Platform (GCP) for your OpenShift Container Platform cluster to use. One way to create this component is to modify the provided Deployment Manager template.



NOTE

If you do not use the provided Deployment Manager template to create your GCP infrastructure, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

Prerequisites

- Configure a GCP account.
- Generate the Ignition config files for your cluster.
- Create and configure a VPC and associated subnets in GCP.

Procedure

1. Copy the template from the **Deployment Manager template for the private DNS**section of this topic and save it as **02_dns.py** on your computer. This template describes the private DNS objects that your cluster requires.

2. Create a **02_dns.yaml** resource definition file:

```
$ cat <<EOF >02_dns.yaml
imports:
- path: 02_dns.py

resources:
- name: cluster-dns
  type: 02_dns.py
  properties:
    infra_id: '${INFRA_ID}' 1
    cluster_domain: '${CLUSTER_NAME}.${BASE_DOMAIN}' 2
    cluster_network: '${CLUSTER_NETWORK}' 3
EOF
```

1. **infra_id** is the **INFRA_ID** infrastructure name from the extraction step.
2. **cluster_domain** is the domain for the cluster, for example **openshift.example.com**.
3. **cluster_network** is the **selfLink** URL to the cluster network.

3. Create the deployment by using the **gcloud** CLI:

```
$ gcloud deployment-manager deployments create ${INFRA_ID}-dns --config 02_dns.yaml --
project ${HOST_PROJECT} --account ${HOST_PROJECT_ACCOUNT}
```

4. The templates do not create DNS entries due to limitations of Deployment Manager, so you must create them manually:

   a. Add the internal DNS entries:

```
$ if [ -f transaction.yaml ]; then rm transaction.yaml; fi
$ gcloud dns record-sets transaction start --zone ${INFRA_ID}-private-zone --project
${HOST_PROJECT} --account ${HOST_PROJECT_ACCOUNT}
$ gcloud dns record-sets transaction add ${CLUSTER_IP} --name
api.${CLUSTER_NAME}.${BASE_DOMAIN}. --ttl 60 --type A --zone ${INFRA_ID}-
private-zone --project ${HOST_PROJECT} --account ${HOST_PROJECT_ACCOUNT}
$ gcloud dns record-sets transaction add ${CLUSTER_IP} --name api-
int.${CLUSTER_NAME}.${BASE_DOMAIN}. --ttl 60 --type A --zone ${INFRA_ID}-
private-zone --project ${HOST_PROJECT} --account ${HOST_PROJECT_ACCOUNT}
$ gcloud dns record-sets transaction execute --zone ${INFRA_ID}-private-zone --project
${HOST_PROJECT} --account ${HOST_PROJECT_ACCOUNT}
```

   b. For an external cluster, also add the external DNS entries:

```
$ if [ -f transaction.yaml ]; then rm transaction.yaml; fi
$ gcloud --account=${HOST_PROJECT_ACCOUNT} --project=${HOST_PROJECT} dns
record-sets transaction start --zone ${BASE_DOMAIN_ZONE_NAME}
$ gcloud --account=${HOST_PROJECT_ACCOUNT} --project=${HOST_PROJECT} dns
record-sets transaction add ${CLUSTER_PUBLIC_IP} --name
```

```
api.${CLUSTER_NAME}.${BASE_DOMAIN}. --ttl 60 --type A --zone
${BASE_DOMAIN_ZONE_NAME}
$ gcloud --account=${HOST_PROJECT_ACCOUNT} --project=${HOST_PROJECT} dns
record-sets transaction execute --zone ${BASE_DOMAIN_ZONE_NAME}
```

8.11.11.1. Deployment Manager template for the private DNS

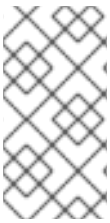
You can use the following Deployment Manager template to deploy the private DNS that you need for your OpenShift Container Platform cluster:

Example 8.62. 02_dns.py Deployment Manager template

```
def GenerateConfig(context):

    resources = [{
        'name': context.properties['infra_id'] + '-private-zone',
        'type': 'dns.v1.managedZone',
        'properties': {
            'description': '',
            'dnsName': context.properties['cluster_domain'] + '.',
            'visibility': 'private',
            'privateVisibilityConfig': {
                'networks': [{
                    'networkUrl': context.properties['cluster_network']
                }]
            }
        }
    }]

    return {'resources': resources}
```

8.11.12. Creating firewall rules in GCP

You must create firewall rules in Google Cloud Platform (GCP) for your OpenShift Container Platform cluster to use. One way to create these components is to modify the provided Deployment Manager template.



NOTE

If you do not use the provided Deployment Manager template to create your GCP infrastructure, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

Prerequisites

- Configure a GCP account.
- Generate the Ignition config files for your cluster.
- Create and configure a VPC and associated subnets in GCP.

Procedure

1. Copy the template from the **Deployment Manager template for firewall rules**section of this topic and save it as **03_firewall.py** on your computer. This template describes the security groups that your cluster requires.

2. Create a **03_firewall.yaml** resource definition file:

```
$ cat <<EOF >03_firewall.yaml
imports:
- path: 03_firewall.py

resources:
- name: cluster-firewall
  type: 03_firewall.py
  properties:
    allowed_external_cidr: '0.0.0.0/0' (1)
    infra_id: '${INFRA_ID}' (2)
    cluster_network: '${CLUSTER_NETWORK}' (3)
    network_cidr: '${NETWORK_CIDR}' (4)
EOF
```

(1) **allowed_external_cidr** is the CIDR range that can access the cluster API and SSH to the bootstrap host. For an internal cluster, set this value to **${NETWORK_CIDR}**.

(2) **infra_id** is the **INFRA_ID** infrastructure name from the extraction step.

(3) **cluster_network** is the **selfLink** URL to the cluster network.

(4) **network_cidr** is the CIDR of the VPC network, for example **10.0.0.0/16**.

3. Create the deployment by using the **gcloud** CLI:

```
$ gcloud deployment-manager deployments create ${INFRA_ID}-firewall --config
03_firewall.yaml --project ${HOST_PROJECT} --account ${HOST_PROJECT_ACCOUNT}
```

8.11.12.1. Deployment Manager template for firewall rules

You can use the following Deployment Manager template to deploy the firewall rues that you need for your OpenShift Container Platform cluster:

Example 8.63. 03_firewall.py Deployment Manager template

```
def GenerateConfig(context):

  resources = [{
    'name': context.properties['infra_id'] + '-bootstrap-in-ssh',
    'type': 'compute.v1.firewall',
    'properties': {
      'network': context.properties['cluster_network'],
      'allowed': [{
        'IPProtocol': 'tcp',
        'ports': ['22']
      }],
```

```
            'sourceRanges': [context.properties['allowed_external_cidr']],
            'targetTags': [context.properties['infra_id'] + '-bootstrap']
        }
    }, {
        'name': context.properties['infra_id'] + '-api',
        'type': 'compute.v1.firewall',
        'properties': {
            'network': context.properties['cluster_network'],
            'allowed': [{
                'IPProtocol': 'tcp',
                'ports': ['6443']
            }],
            'sourceRanges': [context.properties['allowed_external_cidr']],
            'targetTags': [context.properties['infra_id'] + '-master']
        }
    }, {
        'name': context.properties['infra_id'] + '-health-checks',
        'type': 'compute.v1.firewall',
        'properties': {
            'network': context.properties['cluster_network'],
            'allowed': [{
                'IPProtocol': 'tcp',
                'ports': ['6080', '6443', '22624']
            }],
            'sourceRanges': ['35.191.0.0/16', '130.211.0.0/22', '209.85.152.0/22', '209.85.204.0/22'],
            'targetTags': [context.properties['infra_id'] + '-master']
        }
    }, {
        'name': context.properties['infra_id'] + '-etcd',
        'type': 'compute.v1.firewall',
        'properties': {
            'network': context.properties['cluster_network'],
            'allowed': [{
                'IPProtocol': 'tcp',
                'ports': ['2379-2380']
            }],
            'sourceTags': [context.properties['infra_id'] + '-master'],
            'targetTags': [context.properties['infra_id'] + '-master']
        }
    }, {
        'name': context.properties['infra_id'] + '-control-plane',
        'type': 'compute.v1.firewall',
        'properties': {
            'network': context.properties['cluster_network'],
            'allowed': [{
                'IPProtocol': 'tcp',
                'ports': ['10257']
            },{
                'IPProtocol': 'tcp',
                'ports': ['10259']
            },{
                'IPProtocol': 'tcp',
                'ports': ['22623']
            }],
            'sourceTags': [
                context.properties['infra_id'] + '-master',
```

```
                context.properties['infra_id'] + '-worker'
            ],
            'targetTags': [context.properties['infra_id'] + '-master']
        }
    }, {
        'name': context.properties['infra_id'] + '-internal-network',
        'type': 'compute.v1.firewall',
        'properties': {
            'network': context.properties['cluster_network'],
            'allowed': [{
                'IPProtocol': 'icmp'
            },{
                'IPProtocol': 'tcp',
                'ports': ['22']
            }],
            'sourceRanges': [context.properties['network_cidr']],
            'targetTags': [
                context.properties['infra_id'] + '-master',
                context.properties['infra_id'] + '-worker'
            ]
        }
    }, {
        'name': context.properties['infra_id'] + '-internal-cluster',
        'type': 'compute.v1.firewall',
        'properties': {
            'network': context.properties['cluster_network'],
            'allowed': [{
                'IPProtocol': 'udp',
                'ports': ['4789', '6081']
            },{
                'IPProtocol': 'udp',
                'ports': ['500', '4500']
            },{
                'IPProtocol': 'esp',
            },{
                'IPProtocol': 'tcp',
                'ports': ['9000-9999']
            },{
                'IPProtocol': 'udp',
                'ports': ['9000-9999']
            },{
                'IPProtocol': 'tcp',
                'ports': ['10250']
            },{
                'IPProtocol': 'tcp',
                'ports': ['30000-32767']
            },{
                'IPProtocol': 'udp',
                'ports': ['30000-32767']
            }],
            'sourceTags': [
                context.properties['infra_id'] + '-master',
                context.properties['infra_id'] + '-worker'
            ],
            'targetTags': [
                context.properties['infra_id'] + '-master',
```

```
            context.properties['infra_id'] + '-worker'
        ]
    }
}]

return {'resources': resources}
```

8.11.13. Creating IAM roles in GCP

You must create IAM roles in Google Cloud Platform (GCP) for your OpenShift Container Platform cluster to use. One way to create these components is to modify the provided Deployment Manager template.

NOTE

If you do not use the provided Deployment Manager template to create your GCP infrastructure, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

Prerequisites

- Configure a GCP account.
- Generate the Ignition config files for your cluster.
- Create and configure a VPC and associated subnets in GCP.

Procedure

1. Copy the template from the **Deployment Manager template for IAM roles**section of this topic and save it as **03_iam.py** on your computer. This template describes the IAM roles that your cluster requires.
2. Create a **03_iam.yaml** resource definition file:

```
$ cat <<EOF >03_iam.yaml
imports:
- path: 03_iam.py
resources:
- name: cluster-iam
  type: 03_iam.py
  properties:
    infra_id: '${INFRA_ID}' (1)
EOF
```

(1) **infra_id** is the **INFRA_ID** infrastructure name from the extraction step.

3. Create the deployment by using the **gcloud** CLI:

```
$ gcloud deployment-manager deployments create ${INFRA_ID}-iam --config 03_iam.yaml
```

4. Export the variable for the master service account:

```
$ export MASTER_SERVICE_ACCOUNT=(`gcloud iam service-accounts list --filter
"email~^${INFRA_ID}-m@${PROJECT_NAME}." --format json | jq -r '.[0].email'`)
```

5. Export the variable for the worker service account:

```
$ export WORKER_SERVICE_ACCOUNT=(`gcloud iam service-accounts list --filter
"email~^${INFRA_ID}-w@${PROJECT_NAME}." --format json | jq -r '.[0].email'`)
```

6. Assign the permissions that the installation program requires to the service accounts for the subnets that host the control plane and compute subnets:

   a. Grant the **networkViewer** role of the project that hosts your shared VPC to the master service account:

```
$ gcloud --account=${HOST_PROJECT_ACCOUNT} --project=${HOST_PROJECT}
projects add-iam-policy-binding ${HOST_PROJECT} --member
"serviceAccount:${MASTER_SERVICE_ACCOUNT}" --role
"roles/compute.networkViewer"
```

   b. Grant the **networkUser** role to the master service account for the control plane subnet:

```
$ gcloud --account=${HOST_PROJECT_ACCOUNT} --project=${HOST_PROJECT}
compute networks subnets add-iam-policy-binding
"${HOST_PROJECT_CONTROL_SUBNET}" --member
"serviceAccount:${MASTER_SERVICE_ACCOUNT}" --role "roles/compute.networkUser"
--region ${REGION}
```

   c. Grant the **networkUser** role to the worker service account for the control plane subnet:

```
$ gcloud --account=${HOST_PROJECT_ACCOUNT} --project=${HOST_PROJECT}
compute networks subnets add-iam-policy-binding
"${HOST_PROJECT_CONTROL_SUBNET}" --member
"serviceAccount:${WORKER_SERVICE_ACCOUNT}" --role
"roles/compute.networkUser" --region ${REGION}
```

   d. Grant the **networkUser** role to the master service account for the compute subnet:

```
$ gcloud --account=${HOST_PROJECT_ACCOUNT} --project=${HOST_PROJECT}
compute networks subnets add-iam-policy-binding
"${HOST_PROJECT_COMPUTE_SUBNET}" --member
"serviceAccount:${MASTER_SERVICE_ACCOUNT}" --role "roles/compute.networkUser"
--region ${REGION}
```

   e. Grant the **networkUser** role to the worker service account for the compute subnet:

```
$ gcloud --account=${HOST_PROJECT_ACCOUNT} --project=${HOST_PROJECT}
compute networks subnets add-iam-policy-binding
"${HOST_PROJECT_COMPUTE_SUBNET}" --member
"serviceAccount:${WORKER_SERVICE_ACCOUNT}" --role
"roles/compute.networkUser" --region ${REGION}
```

7. The templates do not create the policy bindings due to limitations of Deployment Manager, so you must create them manually:

```
$ gcloud projects add-iam-policy-binding ${PROJECT_NAME} --member
"serviceAccount:${MASTER_SERVICE_ACCOUNT}" --role "roles/compute.instanceAdmin"
$ gcloud projects add-iam-policy-binding ${PROJECT_NAME} --member
"serviceAccount:${MASTER_SERVICE_ACCOUNT}" --role "roles/compute.networkAdmin"
$ gcloud projects add-iam-policy-binding ${PROJECT_NAME} --member
"serviceAccount:${MASTER_SERVICE_ACCOUNT}" --role "roles/compute.securityAdmin"
$ gcloud projects add-iam-policy-binding ${PROJECT_NAME} --member
"serviceAccount:${MASTER_SERVICE_ACCOUNT}" --role "roles/iam.serviceAccountUser"
$ gcloud projects add-iam-policy-binding ${PROJECT_NAME} --member
"serviceAccount:${MASTER_SERVICE_ACCOUNT}" --role "roles/storage.admin"

$ gcloud projects add-iam-policy-binding ${PROJECT_NAME} --member
"serviceAccount:${WORKER_SERVICE_ACCOUNT}" --role "roles/compute.viewer"
$ gcloud projects add-iam-policy-binding ${PROJECT_NAME} --member
"serviceAccount:${WORKER_SERVICE_ACCOUNT}" --role "roles/storage.admin"
```

8. Create a service account key and store it locally for later use:

```
$ gcloud iam service-accounts keys create service-account-key.json --iam-
account=${MASTER_SERVICE_ACCOUNT}
```

8.11.13.1. Deployment Manager template for IAM roles

You can use the following Deployment Manager template to deploy the IAM roles that you need for your OpenShift Container Platform cluster:

Example 8.64. 03_iam.py Deployment Manager template

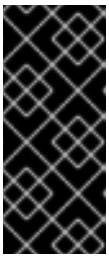
```
def GenerateConfig(context):

    resources = [{
        'name': context.properties['infra_id'] + '-master-node-sa',
        'type': 'iam.v1.serviceAccount',
        'properties': {
            'accountId': context.properties['infra_id'] + '-m',
            'displayName': context.properties['infra_id'] + '-master-node'
        }
    }, {
        'name': context.properties['infra_id'] + '-worker-node-sa',
        'type': 'iam.v1.serviceAccount',
        'properties': {
            'accountId': context.properties['infra_id'] + '-w',
            'displayName': context.properties['infra_id'] + '-worker-node'
        }
    }]

    return {'resources': resources}
```

8.11.14. Creating the RHCOS cluster image for the GCP infrastructure

You must use a valid Red Hat Enterprise Linux CoreOS (RHCOS) image for Google Cloud Platform (GCP) for your OpenShift Container Platform nodes.

Procedure

1. Obtain the RHCOS image from the RHCOS image mirror page.



IMPORTANT

The RHCOS images might not change with every release of OpenShift Container Platform. You must download an image with the highest version that is less than or equal to the OpenShift Container Platform version that you install. Use the image version that matches your OpenShift Container Platform version if it is available.

The file name contains the OpenShift Container Platform version number in the format **rhcos-<version>-<arch>-gcp.<arch>.tar.gz**.

2. Create the Google storage bucket:

```
$ gsutil mb gs://<bucket_name>
```

3. Upload the RHCOS image to the Google storage bucket:

```
$ gsutil cp <downloaded_image_file_path>/rhcos-<version>-x86_64-gcp.x86_64.tar.gz
gs://<bucket_name>
```

4. Export the uploaded RHCOS image location as a variable:

```
$ export IMAGE_SOURCE=gs://<bucket_name>/rhcos-<version>-x86_64-gcp.x86_64.tar.gz
```

5. Create the cluster image:

```
$ gcloud compute images create "${INFRA_ID}-rhcos-image" \
    --source-uri="${IMAGE_SOURCE}"
```

8.11.15. Creating the bootstrap machine in GCP

You must create the bootstrap machine in Google Cloud Platform (GCP) to use during OpenShift Container Platform cluster initialization. One way to create this machine is to modify the provided Deployment Manager template.

NOTE

If you do not use the provided Deployment Manager template to create your bootstrap machine, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

Prerequisites

- Configure a GCP account.

- Generate the Ignition config files for your cluster.
- Create and configure a VPC and associated subnets in GCP.
- Create and configure networking and load balancers in GCP.
- Create control plane and compute roles.
- Ensure pyOpenSSL is installed.

Procedure

1. Copy the template from the **Deployment Manager template for the bootstrap machine** section of this topic and save it as **04_bootstrap.py** on your computer. This template describes the bootstrap machine that your cluster requires.
2. Export the location of the Red Hat Enterprise Linux CoreOS (RHCOS) image that the installation program requires:

```
$ export CLUSTER_IMAGE=(`gcloud compute images describe ${INFRA_ID}-rhcos-image --format json | jq -r .selfLink`)
```

3. Create a bucket and upload the **bootstrap.ign** file:

```
$ gsutil mb gs://${INFRA_ID}-bootstrap-ignition
```

```
$ gsutil cp <installation_directory>/bootstrap.ign gs://${INFRA_ID}-bootstrap-ignition/
```

4. Create a signed URL for the bootstrap instance to use to access the Ignition config. Export the URL from the output as a variable:

```
$ export BOOTSTRAP_IGN=`gsutil signurl -d 1h service-account-key.json gs://${INFRA_ID}-bootstrap-ignition/bootstrap.ign | grep "^gs:" | awk '{print $5}'`
```

5. Create a **04_bootstrap.yaml** resource definition file:

```
$ cat <<EOF >04_bootstrap.yaml
imports:
- path: 04_bootstrap.py

resources:
- name: cluster-bootstrap
  type: 04_bootstrap.py
  properties:
    infra_id: '${INFRA_ID}' 1
    region: '${REGION}' 2
    zone: '${ZONE_0}' 3

    cluster_network: '${CLUSTER_NETWORK}' 4
    control_subnet: '${CONTROL_SUBNET}' 5
    image: '${CLUSTER_IMAGE}' 6
    machine_type: 'n1-standard-4' 7
    root_volume_size: '128' 8
```

```
    bootstrap_ign: '${BOOTSTRAP_IGN}' 9
EOF
```

1. **infra_id** is the **INFRA_ID** infrastructure name from the extraction step.
2. **region** is the region to deploy the cluster into, for example **us-central1**.
3. **zone** is the zone to deploy the bootstrap instance into, for example **us-central1-b**.
4. **cluster_network** is the **selfLink** URL to the cluster network.
5. **control_subnet** is the **selfLink** URL to the control subnet.
6. **image** is the **selfLink** URL to the RHCOS image.
7. **machine_type** is the machine type of the instance, for example **n1-standard-4**.
8. **root_volume_size** is the boot disk size for the bootstrap machine.
9. **bootstrap_ign** is the URL output when creating a signed URL.

6. Create the deployment by using the **gcloud** CLI:

```
$ gcloud deployment-manager deployments create ${INFRA_ID}-bootstrap --config
04_bootstrap.yaml
```

7. Add the bootstrap instance to the internal load balancer instance group:

```
$ gcloud compute instance-groups unmanaged add-instances ${INFRA_ID}-bootstrap-ig --
zone=${ZONE_0} --instances=${INFRA_ID}-bootstrap
```

8. Add the bootstrap instance group to the internal load balancer backend service:

```
$ gcloud compute backend-services add-backend ${INFRA_ID}-api-internal-backend-service
--region=${REGION} --instance-group=${INFRA_ID}-bootstrap-ig --instance-group-
zone=${ZONE_0}
```

8.11.15.1. Deployment Manager template for the bootstrap machine

You can use the following Deployment Manager template to deploy the bootstrap machine that you need for your OpenShift Container Platform cluster:

Example 8.65. 04_bootstrap.py Deployment Manager template

```
def GenerateConfig(context):

    resources = [{
        'name': context.properties['infra_id'] + '-bootstrap-public-ip',
        'type': 'compute.v1.address',
        'properties': {
            'region': context.properties['region']
        }
    }, {
```

```
        'name': context.properties['infra_id'] + '-bootstrap',
        'type': 'compute.v1.instance',
        'properties': {
            'disks': [{
                'autoDelete': True,
                'boot': True,
                'initializeParams': {
                    'diskSizeGb': context.properties['root_volume_size'],
                    'sourceImage': context.properties['image']
                }
            }],
            'machineType': 'zones/' + context.properties['zone'] + '/machineTypes/' +
context.properties['machine_type'],
            'metadata': {
                'items': [{
                    'key': 'user-data',
                    'value': '{"ignition":{"config":{"replace":{"source":"' + context.properties['bootstrap_ign']
+ '"}},"version":"3.2.0"}}',
                }]
            },
            'networkInterfaces': [{
                'subnetwork': context.properties['control_subnet'],
                'accessConfigs': [{
                    'natIP': '$(ref.' + context.properties['infra_id'] + '-bootstrap-public-ip.address)'
                }]
            }],
            'tags': {
                'items': [
                    context.properties['infra_id'] + '-master',
                    context.properties['infra_id'] + '-bootstrap'
                ]
            },
            'zone': context.properties['zone']
        }
    }, {
        'name': context.properties['infra_id'] + '-bootstrap-ig',
        'type': 'compute.v1.instanceGroup',
        'properties': {
            'namedPorts': [
                {
                    'name': 'ignition',
                    'port': 22623
                }, {
                    'name': 'https',
                    'port': 6443
                }
            ],
            'network': context.properties['cluster_network'],
            'zone': context.properties['zone']
        }
    }]

    return {'resources': resources}
```

8.11.16. Creating the control plane machines in GCP

You must create the control plane machines in Google Cloud Platform (GCP) for your cluster to use. One way to create these machines is to modify the provided Deployment Manager template.

NOTE

If you do not use the provided Deployment Manager template to create your control plane machines, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

Prerequisites

- Configure a GCP account.
- Generate the Ignition config files for your cluster.
- Create and configure a VPC and associated subnets in GCP.
- Create and configure networking and load balancers in GCP.
- Create control plane and compute roles.
- Create the bootstrap machine.

Procedure

1. Copy the template from the **Deployment Manager template for control plane machines** section of this topic and save it as **05_control_plane.py** on your computer. This template describes the control plane machines that your cluster requires.
2. Export the following variable required by the resource definition:

```
$ export MASTER_IGNITION=`cat <installation_directory>/master.ign`
```

3. Create a **05_control_plane.yaml** resource definition file:

```
$ cat <<EOF >05_control_plane.yaml
imports:
- path: 05_control_plane.py

resources:
- name: cluster-control-plane
  type: 05_control_plane.py
  properties:
    infra_id: '${INFRA_ID}' (1)
    zones: (2)
    - '${ZONE_0}'
    - '${ZONE_1}'
    - '${ZONE_2}'

    control_subnet: '${CONTROL_SUBNET}' (3)
    image: '${CLUSTER_IMAGE}' (4)
    machine_type: 'n1-standard-4' (5)
```

```
    root_volume_size: '128'
    service_account_email: '${MASTER_SERVICE_ACCOUNT}' 6

    ignition: '${MASTER_IGNITION}' 7
EOF
```

1. **infra_id** is the **INFRA_ID** infrastructure name from the extraction step.
2. **zones** are the zones to deploy the control plane instances into, for example **us-central1-a**, **us-central1-b**, and **us-central1-c**.
3. **control_subnet** is the **selfLink** URL to the control subnet.
4. **image** is the **selfLink** URL to the RHCOS image.
5. **machine_type** is the machine type of the instance, for example **n1-standard-4**.
6. **service_account_email** is the email address for the master service account that you created.
7. **ignition** is the contents of the **master.ign** file.

4. Create the deployment by using the **gcloud** CLI:

```
$ gcloud deployment-manager deployments create ${INFRA_ID}-control-plane --config
05_control_plane.yaml
```

5. The templates do not manage load balancer membership due to limitations of Deployment Manager, so you must add the control plane machines manually.

   - Run the following commands to add the control plane machines to the appropriate instance groups:

```
$ gcloud compute instance-groups unmanaged add-instances ${INFRA_ID}-master-
${ZONE_0}-ig --zone=${ZONE_0} --instances=${INFRA_ID}-master-0
```

```
$ gcloud compute instance-groups unmanaged add-instances ${INFRA_ID}-master-
${ZONE_1}-ig --zone=${ZONE_1} --instances=${INFRA_ID}-master-1
```

```
$ gcloud compute instance-groups unmanaged add-instances ${INFRA_ID}-master-
${ZONE_2}-ig --zone=${ZONE_2} --instances=${INFRA_ID}-master-2
```

   - For an external cluster, you must also run the following commands to add the control plane machines to the target pools:

```
$ gcloud compute target-pools add-instances ${INFRA_ID}-api-target-pool --instances-
zone="${ZONE_0}" --instances=${INFRA_ID}-master-0
```

```
$ gcloud compute target-pools add-instances ${INFRA_ID}-api-target-pool --instances-
zone="${ZONE_1}" --instances=${INFRA_ID}-master-1
```

```
$ gcloud compute target-pools add-instances ${INFRA_ID}-api-target-pool --instances-
zone="${ZONE_2}" --instances=${INFRA_ID}-master-2
```

-

8.11.16.1. Deployment Manager template for control plane machines

You can use the following Deployment Manager template to deploy the control plane machines that you need for your OpenShift Container Platform cluster:

Example 8.66. 05_control_plane.py Deployment Manager template

```
def GenerateConfig(context):

    resources = [{
        'name': context.properties['infra_id'] + '-master-0',
        'type': 'compute.v1.instance',
        'properties': {
            'disks': [{
                'autoDelete': True,
                'boot': True,
                'initializeParams': {
                    'diskSizeGb': context.properties['root_volume_size'],
                    'diskType': 'zones/' + context.properties['zones'][0] + '/diskTypes/pd-ssd',
                    'sourceImage': context.properties['image']
                }
            }],
            'machineType': 'zones/' + context.properties['zones'][0] + '/machineTypes/' +
context.properties['machine_type'],
            'metadata': {
                'items': [{
                    'key': 'user-data',
                    'value': context.properties['ignition']
                }]
            },
            'networkInterfaces': [{
                'subnetwork': context.properties['control_subnet']
            }],
            'serviceAccounts': [{
                'email': context.properties['service_account_email'],
                'scopes': ['https://www.googleapis.com/auth/cloud-platform']
            }],
            'tags': {
                'items': [
                    context.properties['infra_id'] + '-master',
                ]
            },
            'zone': context.properties['zones'][0]
        }
    }, {
        'name': context.properties['infra_id'] + '-master-1',
        'type': 'compute.v1.instance',
        'properties': {
            'disks': [{
                'autoDelete': True,
                'boot': True,
                'initializeParams': {
                    'diskSizeGb': context.properties['root_volume_size'],
                    'diskType': 'zones/' + context.properties['zones'][1] + '/diskTypes/pd-ssd',
```

```
                'sourceImage': context.properties['image']
            }
        }],
        'machineType': 'zones/' + context.properties['zones'][1] + '/machineTypes/' +
context.properties['machine_type'],
        'metadata': {
            'items': [{
                'key': 'user-data',
                'value': context.properties['ignition']
            }]
        },
        'networkInterfaces': [{
            'subnetwork': context.properties['control_subnet']
        }],
        'serviceAccounts': [{
            'email': context.properties['service_account_email'],
            'scopes': ['https://www.googleapis.com/auth/cloud-platform']
        }],
        'tags': {
            'items': [
                context.properties['infra_id'] + '-master',
            ]
        },
        'zone': context.properties['zones'][1]
    }
}, {
    'name': context.properties['infra_id'] + '-master-2',
    'type': 'compute.v1.instance',
    'properties': {
        'disks': [{
            'autoDelete': True,
            'boot': True,
            'initializeParams': {
                'diskSizeGb': context.properties['root_volume_size'],
                'diskType': 'zones/' + context.properties['zones'][2] + '/diskTypes/pd-ssd',
                'sourceImage': context.properties['image']
            }
        }],
        'machineType': 'zones/' + context.properties['zones'][2] + '/machineTypes/' +
context.properties['machine_type'],
        'metadata': {
            'items': [{
                'key': 'user-data',
                'value': context.properties['ignition']
            }]
        },
        'networkInterfaces': [{
            'subnetwork': context.properties['control_subnet']
        }],
        'serviceAccounts': [{
            'email': context.properties['service_account_email'],
            'scopes': ['https://www.googleapis.com/auth/cloud-platform']
        }],
        'tags': {
            'items': [
                context.properties['infra_id'] + '-master',
```

```
            ]
        },
        'zone': context.properties['zones'][2]
    }
}]

return {'resources': resources}
```

8.11.17. Wait for bootstrap completion and remove bootstrap resources in GCP

After you create all of the required infrastructure in Google Cloud Platform (GCP), wait for the bootstrap process to complete on the machines that you provisioned by using the Ignition config files that you generated with the installation program.

Prerequisites

- Configure a GCP account.
- Generate the Ignition config files for your cluster.
- Create and configure a VPC and associated subnets in GCP.
- Create and configure networking and load balancers in GCP.
- Create control plane and compute roles.
- Create the bootstrap machine.
- Create the control plane machines.

Procedure

1. Change to the directory that contains the installation program and run the following command:

```
$ ./openshift-install wait-for bootstrap-complete --dir <installation_directory> \ 1
    --log-level info 2
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

If the command exits without a **FATAL** warning, your production control plane has initialized.

2. Delete the bootstrap resources:

```
$ gcloud compute backend-services remove-backend ${INFRA_ID}-api-internal-backend-
service --region=${REGION} --instance-group=${INFRA_ID}-bootstrap-ig --instance-group-
zone=${ZONE_0}
```

```
$ gsutil rm gs://${INFRA_ID}-bootstrap-ignition/bootstrap.ign
```

```
$ gsutil rb gs://${INFRA_ID}-bootstrap-ignition
```

```
$ gcloud deployment-manager deployments delete ${INFRA_ID}-bootstrap
```

8.11.18. Creating additional worker machines in GCP

You can create worker machines in Google Cloud Platform (GCP) for your cluster to use by launching individual instances discretely or by automated processes outside the cluster, such as auto scaling groups. You can also take advantage of the built-in cluster scaling mechanisms and the machine API in OpenShift Container Platform.

In this example, you manually launch one instance by using the Deployment Manager template. Additional instances can be launched by including additional resources of type **06_worker.py** in the file.

NOTE

If you do not use the provided Deployment Manager template to create your worker machines, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

Prerequisites

- Configure a GCP account.
- Generate the Ignition config files for your cluster.
- Create and configure a VPC and associated subnets in GCP.
- Create and configure networking and load balancers in GCP.
- Create control plane and compute roles.
- Create the bootstrap machine.
- Create the control plane machines.

Procedure

1. Copy the template from the **Deployment Manager template for worker machines** section of this topic and save it as **06_worker.py** on your computer. This template describes the worker machines that your cluster requires.
2. Export the variables that the resource definition uses.
   a. Export the subnet that hosts the compute machines:

```
$ export COMPUTE_SUBNET=(`gcloud compute networks subnets describe
${HOST_PROJECT_COMPUTE_SUBNET} --region=${REGION} --project
${HOST_PROJECT} --account ${HOST_PROJECT_ACCOUNT} --format json | jq -r
.selfLink`)
```

   b. Export the email address for your service account:

```
$ export WORKER_SERVICE_ACCOUNT=(`gcloud iam service-accounts list --filter
"email~^${INFRA_ID}-w@${PROJECT_NAME}." --format json | jq -r '.[0].email'`)
```

c. Export the location of the compute machine Ignition config file:

```
$ export WORKER_IGNITION=`cat <installation_directory>/worker.ign`
```

3. Create a **06_worker.yaml** resource definition file:

```
$ cat <<EOF >06_worker.yaml
imports:
- path: 06_worker.py

resources:
- name: 'worker-0' (1)
  type: 06_worker.py
  properties:
    infra_id: '${INFRA_ID}' (2)
    zone: '${ZONE_0}' (3)
    compute_subnet: '${COMPUTE_SUBNET}' (4)
    image: '${CLUSTER_IMAGE}' (5)
    machine_type: 'n1-standard-4' (6)
    root_volume_size: '128'
    service_account_email: '${WORKER_SERVICE_ACCOUNT}' (7)
    ignition: '${WORKER_IGNITION}' (8)
- name: 'worker-1'
  type: 06_worker.py
  properties:
    infra_id: '${INFRA_ID}' (9)
    zone: '${ZONE_1}' (10)
    compute_subnet: '${COMPUTE_SUBNET}' (11)
    image: '${CLUSTER_IMAGE}' (12)
    machine_type: 'n1-standard-4' (13)
    root_volume_size: '128'
    service_account_email: '${WORKER_SERVICE_ACCOUNT}' (14)
    ignition: '${WORKER_IGNITION}' (15)
EOF
```

(1) **name** is the name of the worker machine, for example **worker-0**.

(2) (9) **infra_id** is the **INFRA_ID** infrastructure name from the extraction step.

(3) (10) **zone** is the zone to deploy the worker machine into, for example **us-central1-a**.

(4) (11) **compute_subnet** is the **selfLink** URL to the compute subnet.

(5) (12) **image** is the **selfLink** URL to the RHCOS image. [1]

(6) (13) **machine_type** is the machine type of the instance, for example **n1-standard-4**.

(7) (14) **service_account_email** is the email address for the worker service account that you created.

8 15 **ignition** is the contents of the **worker.ign** file.

4. Optional: If you want to launch additional instances, include additional resources of type **06_worker.py** in your **06_worker.yaml** resource definition file.

5. Create the deployment by using the **gcloud** CLI:

```
$ gcloud deployment-manager deployments create ${INFRA_ID}-worker --config
06_worker.yaml
```

1. To use a GCP Marketplace image, specify the offer to use:

   - OpenShift Container Platform: **https://www.googleapis.com/compute/v1/projects/redhat-marketplace-public/global/images/redhat-coreos-ocp-48-x86-64-202210040145**
   - OpenShift Platform Plus: **https://www.googleapis.com/compute/v1/projects/redhat-marketplace-public/global/images/redhat-coreos-opp-48-x86-64-202206140145**
   - OpenShift Kubernetes Engine: **https://www.googleapis.com/compute/v1/projects/redhat-marketplace-public/global/images/redhat-coreos-oke-48-x86-64-202206140145**

8.11.18.1. Deployment Manager template for worker machines

You can use the following Deployment Manager template to deploy the worker machines that you need for your OpenShift Container Platform cluster:

Example 8.67. 06_worker.py Deployment Manager template

```
def GenerateConfig(context):

    resources = [{
        'name': context.properties['infra_id'] + '-' + context.env['name'],
        'type': 'compute.v1.instance',
        'properties': {
            'disks': [{
                'autoDelete': True,
                'boot': True,
                'initializeParams': {
                    'diskSizeGb': context.properties['root_volume_size'],
                    'sourceImage': context.properties['image']
                }
            }],
            'machineType': 'zones/' + context.properties['zone'] + '/machineTypes/' +
context.properties['machine_type'],
            'metadata': {
                'items': [{
                    'key': 'user-data',
                    'value': context.properties['ignition']
                }]
            },
            'networkInterfaces': [{
                'subnetwork': context.properties['compute_subnet']
            }],
```

```
            'serviceAccounts': [{
                'email': context.properties['service_account_email'],
                'scopes': ['https://www.googleapis.com/auth/cloud-platform']
            }],
            'tags': {
                'items': [
                    context.properties['infra_id'] + '-worker',
                ]
            },
            'zone': context.properties['zone']
        }
    }]

    return {'resources': resources}
```

8.11.19. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.

IMPORTANT

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.11. Download and install the new version of **oc**.

Installing the OpenShift CLI on Linux

You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the architecture in the **Product Variant** drop-down menu.
3. Select the appropriate version in the **Version** drop-down menu.
4. Click **Download Now** next to the **OpenShift v4.11 Linux Client** entry and save the file.
5. Unpack the archive:

```
$ tar xvf <file>
```

6. Place the **oc** binary in a directory that is on your **PATH**.
   To check your **PATH**, execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

Installing the OpenShift CLI on Windows
You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.
   To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
C:\> oc <command>
```

Installing the OpenShift CLI on macOS
You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 macOS Client** entry and save the file.

NOTE

For macOS arm64, choose the **OpenShift v4.11 macOS arm64 Client** entry.

4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your PATH.
   To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

8.11.20. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

Example output

```
system:admin
```

8.11.21. Approving the certificate signing requests for your machines

When you add machines to a cluster, two pending certificate signing requests (CSRs) are generated for each machine that you added. You must confirm that these CSRs are approved or, if necessary, approve them yourself. The client requests must be approved first, followed by the server requests.

Prerequisites

- You added machines to your cluster.

Procedure

1. Confirm that the cluster recognizes the machines:

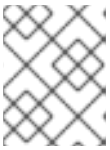
```
$ oc get nodes
```

Example output

```
NAME      STATUS    ROLES   AGE  VERSION
```

```
master-0  Ready    master  63m  v1.24.0
master-1  Ready    master  63m  v1.24.0
master-2  Ready    master  64m  v1.24.0
```

The output lists all of the machines that you created.



NOTE

The preceding output might not include the compute nodes, also known as worker nodes, until some CSRs are approved.

2. Review the pending CSRs and ensure that you see the client requests with the **Pending** or **Approved** status for each machine that you added to the cluster:

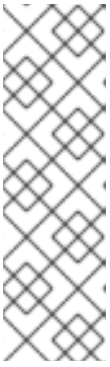
```
$ oc get csr
```

Example output

```
NAME        AGE     REQUESTOR                                                   CONDITION
csr-8b2br   15m     system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper   Pending
csr-8vnps   15m     system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper   Pending
...
```

In this example, two machines are joining the cluster. You might see more approved CSRs in the list.

3. If the CSRs were not approved, after all of the pending CSRs for the machines you added are in **Pending** status, approve the CSRs for your cluster machines:



NOTE

Because the CSRs rotate automatically, approve your CSRs within an hour of adding the machines to the cluster. If you do not approve them within an hour, the certificates will rotate, and more than two certificates will be present for each node. You must approve all of these certificates. After the client CSR is approved, the Kubelet creates a secondary CSR for the serving certificate, which requires manual approval. Then, subsequent serving certificate renewal requests are automatically approved by the **machine-approver** if the Kubelet requests a new certificate with identical parameters.

NOTE

For clusters running on platforms that are not machine API enabled, such as bare metal and other user-provisioned infrastructure, you must implement a method of automatically approving the kubelet serving certificate requests (CSRs). If a request is not approved, then the **oc exec**, **oc rsh**, and **oc logs** commands cannot succeed, because a serving certificate is required when the API server connects to the kubelet. Any operation that contacts the Kubelet endpoint requires this certificate approval to be in place. The method must watch for new CSRs, confirm that the CSR was submitted by the **node-bootstrapper** service account in the **system:node** or **system:admin** groups, and confirm the identity of the node.

- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

1 **<csr_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{{"\n"}}
{{end}}{{end}}' | xargs --no-run-if-empty oc adm certificate approve
```

NOTE

Some Operators might not become available until some CSRs are approved.

4. Now that your client requests are approved, you must review the server requests for each machine that you added to the cluster:

```
$ oc get csr
```

Example output

```
NAME        AGE    REQUESTOR                                                   CONDITION
csr-bfd72   5m26s  system:node:ip-10-0-50-126.us-east-2.compute.internal
Pending
csr-c57lv   5m26s  system:node:ip-10-0-95-157.us-east-2.compute.internal
Pending
...
```

5. If the remaining CSRs are not approved, and are in the **Pending** status, approve the CSRs for your cluster machines:

- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

1 **<csr_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

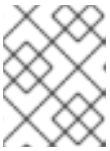
```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{{"\n"}}
{{end}}{{end}}' | xargs oc adm certificate approve
```

6. After all client and server CSRs have been approved, the machines have the **Ready** status. Verify this by running the following command:

```
$ oc get nodes
```

Example output

```
NAME      STATUS    ROLES   AGE  VERSION
master-0  Ready     master  73m  v1.24.0
master-1  Ready     master  73m  v1.24.0
master-2  Ready     master  74m  v1.24.0
worker-0  Ready     worker  11m  v1.24.0
worker-1  Ready     worker  11m  v1.24.0
```



NOTE

It can take a few minutes after approval of the server CSRs for the machines to transition to the **Ready** status.

Additional information

- For more information on CSRs, see Certificate Signing Requests.

8.11.22. Adding the ingress DNS records

DNS zone configuration is removed when creating Kubernetes manifests and generating Ignition configs. You must manually create DNS records that point at the ingress load balancer. You can create either a wildcard ***.apps.{baseDomain}.** or specific records. You can use A, CNAME, and other records per your requirements.

Prerequisites

- Configure a GCP account.
- Remove the DNS Zone configuration when creating Kubernetes manifests and generating Ignition configs.
- Create and configure a VPC and associated subnets in GCP.
- Create and configure networking and load balancers in GCP.
- Create control plane and compute roles.
- Create the bootstrap machine.
- Create the control plane machines.
- Create the worker machines.

Procedure

1. Wait for the Ingress router to create a load balancer and populate the **EXTERNAL-IP** field:

```
$ oc -n openshift-ingress get service router-default
```

Example output

```
NAME            TYPE           CLUSTER-IP     EXTERNAL-IP     PORT(S)                      AGE
router-default  LoadBalancer   172.30.18.154  35.233.157.184
80:32288/TCP,443:31215/TCP   98
```

2. Add the A record to your zones:

- To use A records:

  i. Export the variable for the router IP address:

```
$ export ROUTER_IP=`oc -n openshift-ingress get service router-default --no-
headers | awk '{print $4}'`
```

  ii. Add the A record to the private zones:

```
$ if [ -f transaction.yaml ]; then rm transaction.yaml; fi
$ gcloud dns record-sets transaction start --zone ${INFRA_ID}-private-zone --project
${HOST_PROJECT} --account ${HOST_PROJECT_ACCOUNT}
$ gcloud dns record-sets transaction add ${ROUTER_IP} --name
\*.apps.${CLUSTER_NAME}.${BASE_DOMAIN}. --ttl 300 --type A --zone
${INFRA_ID}-private-zone --project ${HOST_PROJECT} --account
${HOST_PROJECT_ACCOUNT}
$ gcloud dns record-sets transaction execute --zone ${INFRA_ID}-private-zone --
project ${HOST_PROJECT} --account ${HOST_PROJECT_ACCOUNT}
```

  iii. For an external cluster, also add the A record to the public zones:

```
$ if [ -f transaction.yaml ]; then rm transaction.yaml; fi
$ gcloud dns record-sets transaction start --zone ${BASE_DOMAIN_ZONE_NAME} -
-project ${HOST_PROJECT} --account ${HOST_PROJECT_ACCOUNT}
$ gcloud dns record-sets transaction add ${ROUTER_IP} --name
\*.apps.${CLUSTER_NAME}.${BASE_DOMAIN}. --ttl 300 --type A --zone
${BASE_DOMAIN_ZONE_NAME} --project ${HOST_PROJECT} --account
${HOST_PROJECT_ACCOUNT}
$ gcloud dns record-sets transaction execute --zone
${BASE_DOMAIN_ZONE_NAME} --project ${HOST_PROJECT} --account
${HOST_PROJECT_ACCOUNT}
```

- To add explicit domains instead of using a wildcard, create entries for each of the cluster's current routes:

```
$ oc get --all-namespaces -o jsonpath='{range .items[*]}{range .status.ingress[*]}{.host}
{"\n"}{end}{end}' routes
```

Example output

```
oauth-openshift.apps.your.cluster.domain.example.com
console-openshift-console.apps.your.cluster.domain.example.com
downloads-openshift-console.apps.your.cluster.domain.example.com
alertmanager-main-openshift-monitoring.apps.your.cluster.domain.example.com
prometheus-k8s-openshift-monitoring.apps.your.cluster.domain.example.com
```

8.11.23. Adding ingress firewall rules

The cluster requires several firewall rules. If you do not use a shared VPC, these rules are created by the Ingress Controller via the GCP cloud provider. When you use a shared VPC, you can either create cluster-wide firewall rules for all services now or create each rule based on events, when the cluster requests access. By creating each rule when the cluster requests access, you know exactly which firewall rules are required. By creating cluster-wide firewall rules, you can apply the same rule set across multiple clusters.

If you choose to create each rule based on events, you must create firewall rules after you provision the cluster and during the life of the cluster when the console notifies you that rules are missing. Events that are similar to the following event are displayed, and you must add the firewall rules that are required:

```
$ oc get events -n openshift-ingress --field-selector="reason=LoadBalancerManualChange"
```

Example output

```
Firewall change required by security admin: `gcloud compute firewall-rules create k8s-fw-a26e631036a3f46cba28f8df67266d55 --network example-network --description "{\"kubernetes.io/service-name\":\"openshift-ingress/router-default\", \"kubernetes.io/service-ip\":\"35.237.236.234\"}\" --allow tcp:443,tcp:80 --source-ranges 0.0.0.0/0 --target-tags exampl-fqzq7-master,exampl-fqzq7-worker --project example-project`
```

If you encounter issues when creating these rule-based events, you can configure the cluster-wide firewall rules while your cluster is running.

8.11.23.1. Creating cluster-wide firewall rules for a shared VPC in GCP

You can create cluster-wide firewall rules to allow the access that the OpenShift Container Platform cluster requires.

WARNING

If you do not choose to create firewall rules based on cluster events, you must create cluster-wide firewall rules.

Prerequisites

- You exported the variables that the Deployment Manager templates require to deploy your cluster.
- You created the networking and load balancing components in GCP that your cluster requires.

Procedure

1. Add a single firewall rule to allow the Google Cloud Engine health checks to access all of the services. This rule enables the ingress load balancers to determine the health status of their instances.

```
$ gcloud compute firewall-rules create --allow='tcp:30000-32767,udp:30000-32767' --
network="${CLUSTER_NETWORK}" --source-
ranges='130.211.0.0/22,35.191.0.0/16,209.85.152.0/22,209.85.204.0/22' --target-
tags="${INFRA_ID}-master,${INFRA_ID}-worker" ${INFRA_ID}-ingress-hc --
account=${HOST_PROJECT_ACCOUNT} --project=${HOST_PROJECT}
```

2. Add a single firewall rule to allow access to all cluster services:

   - For an external cluster:

```
$ gcloud compute firewall-rules create --allow='tcp:80,tcp:443' --
network="${CLUSTER_NETWORK}" --source-ranges="0.0.0.0/0" --target-
tags="${INFRA_ID}-master,${INFRA_ID}-worker" ${INFRA_ID}-ingress --
account=${HOST_PROJECT_ACCOUNT} --project=${HOST_PROJECT}
```

   - For a private cluster:

```
$ gcloud compute firewall-rules create --allow='tcp:80,tcp:443' --
network="${CLUSTER_NETWORK}" --source-ranges=${NETWORK_CIDR} --target-
tags="${INFRA_ID}-master,${INFRA_ID}-worker" ${INFRA_ID}-ingress --
account=${HOST_PROJECT_ACCOUNT} --project=${HOST_PROJECT}
```

   Because this rule only allows traffic on TCP ports **80** and **443**, ensure that you add all the ports that your services use.

8.11.24. Completing a GCP installation on user-provisioned infrastructure

After you start the OpenShift Container Platform installation on Google Cloud Platform (GCP) user-provisioned infrastructure, you can monitor the cluster events until the cluster is ready.

Prerequisites

- Deploy the bootstrap machine for an OpenShift Container Platform cluster on user-provisioned GCP infrastructure.
- Install the **oc** CLI and log in.

Procedure

1. Complete the cluster installation:

```
$ ./openshift-install --dir <installation_directory> wait-for install-complete 1
```

Example output

```
INFO Waiting up to 30m0s for the cluster to initialize...
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

2. Observe the running state of your cluster.

   a. Run the following command to view the current cluster version and status:

   ```
   $ oc get clusterversion
   ```

   Example output

   ```
   NAME      VERSION   AVAILABLE   PROGRESSING   SINCE   STATUS
   version             False       True          24m     Working towards 4.5.4: 99% complete
   ```

   b. Run the following command to view the Operators managed on the control plane by the Cluster Version Operator (CVO):

   ```
   $ oc get clusteroperators
   ```

   Example output

   ```
   NAME                                       VERSION   AVAILABLE   PROGRESSING   DEGRADED
   SINCE
   authentication                             4.5.4     True        False         False     7m56s
   cloud-credential                           4.5.4     True        False         False     31m
   cluster-autoscaler                         4.5.4     True        False         False     16m
   console                                    4.5.4     True        False         False     10m
   csi-snapshot-controller                    4.5.4     True        False         False     16m
   dns                                        4.5.4     True        False         False     22m
   etcd                                       4.5.4     False       False         False     25s
   image-registry                             4.5.4     True        False         False     16m
   ingress                                    4.5.4     True        False         False     16m
   insights                                   4.5.4     True        False         False     17m
   kube-apiserver                             4.5.4     True        False         False     19m
   kube-controller-manager                    4.5.4     True        False         False     20m
   kube-scheduler                             4.5.4     True        False         False     20m
   ```

```
kube-storage-version-migrator              4.5.4     True        False         False      16m
machine-api                                4.5.4     True        False         False      22m
machine-config                             4.5.4     True        False         False      22m
marketplace                                4.5.4     True        False         False      16m
monitoring                                 4.5.4     True        False         False      10m
network                                    4.5.4     True        False         False      23m
node-tuning                                4.5.4     True        False         False      23m
openshift-apiserver                        4.5.4     True        False         False      17m
openshift-controller-manager               4.5.4     True        False         False      15m
openshift-samples                          4.5.4     True        False         False      16m
operator-lifecycle-manager                 4.5.4     True        False         False      22m
operator-lifecycle-manager-catalog         4.5.4     True        False         False      22m
operator-lifecycle-manager-packageserver   4.5.4     True        False         False      18m
service-ca                                 4.5.4     True        False         False      23m
service-catalog-apiserver                  4.5.4     True        False         False      23m
service-catalog-controller-manager         4.5.4     True        False         False      23m
storage                                    4.5.4     True        False         False      17m
```

c. Run the following command to view your cluster pods:

```
$ oc get pods --all-namespaces
```

Example output

```
NAMESPACE                                          NAME
READY   STATUS      RESTARTS   AGE
kube-system                                        etcd-member-ip-10-0-3-111.us-east-
2.compute.internal              1/1     Running     0          35m
kube-system                                        etcd-member-ip-10-0-3-239.us-east-
2.compute.internal              1/1     Running     0          37m
kube-system                                        etcd-member-ip-10-0-3-24.us-east-
2.compute.internal              1/1     Running     0          35m
openshift-apiserver-operator                       openshift-apiserver-operator-6d6674f4f4-
h7t2t                           1/1     Running     1          37m
openshift-apiserver                                apiserver-fm48r
1/1     Running     0          30m
openshift-apiserver                                apiserver-fxkvv
1/1     Running     0          29m
openshift-apiserver                                apiserver-q85nm
1/1     Running     0          29m
...
openshift-service-ca-operator                      openshift-service-ca-operator-66ff6dc6cd-
9r257                           1/1     Running     0          37m
openshift-service-ca                               apiservice-cabundle-injector-695b6bcbc-cl5hm
1/1     Running     0          35m
openshift-service-ca                               configmap-cabundle-injector-8498544d7-
25qn6                           1/1     Running     0          35m
openshift-service-ca                               service-serving-cert-signer-6445fc9c6-wqdqn
1/1     Running     0          35m
openshift-service-catalog-apiserver-operator       openshift-service-catalog-apiserver-
operator-549f44668b-b5q2w       1/1     Running     0          32m
openshift-service-catalog-controller-manager-operator   openshift-service-catalog-
controller-manager-operator-b78cr2lnm     1/1     Running     0          31m
```

When the current cluster version is **AVAILABLE**, the installation is complete.

8.11.25. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.11, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to OpenShift Cluster Manager Hybrid Cloud Console.

After you confirm that your OpenShift Cluster Manager Hybrid Cloud Console inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, use subscription watch to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

Additional resources

- See About remote health monitoring for more information about the Telemetry service

8.11.26. Next steps

- Customize your cluster.
- If necessary, you can opt out of remote health reporting .

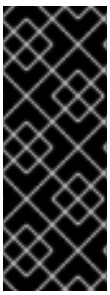
8.12. INSTALLING A CLUSTER ON GCP IN A RESTRICTED NETWORK WITH USER-PROVISIONED INFRASTRUCTURE

In OpenShift Container Platform version 4.11, you can install a cluster on Google Cloud Platform (GCP) that uses infrastructure that you provide and an internal mirror of the installation release content.

IMPORTANT

While you can install an OpenShift Container Platform cluster by using mirrored installation release content, your cluster still requires internet access to use the GCP APIs.

The steps for performing a user-provided infrastructure install are outlined here. Several Deployment Manager templates are provided to assist in completing these steps or to help model your own. You are also free to create the required resources through other methods.



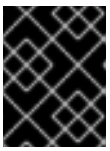
IMPORTANT

The steps for performing a user-provisioned infrastructure installation are provided as an example only. Installing a cluster with infrastructure you provide requires knowledge of the cloud provider and the installation process of OpenShift Container Platform. Several Deployment Manager templates are provided to assist in completing these steps or to help model your own. You are also free to create the required resources through other methods; the templates are just an example.

8.12.1. Prerequisites

- You reviewed details about the OpenShift Container Platform installation and update processes.

- You read the documentation on selecting a cluster installation method and preparing it for users.
- You created a registry on your mirror host and obtained the **imageContentSources** data for your version of OpenShift Container Platform.



IMPORTANT

Because the installation media is on the mirror host, you can use that computer to complete all installation steps.

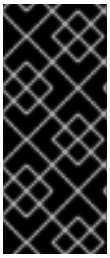
- If you use a firewall, you configured it to allow the sites that your cluster requires access to. While you might need to grant access to more sites, you must grant access to ***.googleapis.com** and **accounts.google.com**.
- If the cloud identity and access management (IAM) APIs are not accessible in your environment, or if you do not want to store an administrator-level credential secret in the **kube-system** namespace, you can manually create and maintain IAM credentials.

8.12.2. About installations in restricted networks

In OpenShift Container Platform 4.11, you can perform an installation that does not require an active connection to the internet to obtain software components. Restricted network installations can be completed using installer-provisioned infrastructure or user-provisioned infrastructure, depending on the cloud platform to which you are installing the cluster.

If you choose to perform a restricted network installation on a cloud platform, you still require access to its cloud APIs. Some cloud functions, like Amazon Web Service's Route 53 DNS and IAM services, require internet access. Depending on your network, you might require less internet access for an installation on bare metal hardware or on VMware vSphere.

To complete a restricted network installation, you must create a registry that mirrors the contents of the OpenShift image registry and contains the installation media. You can create this registry on a mirror host, which can access both the internet and your closed network, or by using other methods that meet your restrictions.



IMPORTANT

Because of the complexity of the configuration for user-provisioned installations, consider completing a standard user-provisioned infrastructure installation before you attempt a restricted network installation using user-provisioned infrastructure. Completing this test installation might make it easier to isolate and troubleshoot any issues that might arise during your installation in a restricted network.

8.12.2.1. Additional limits

Clusters in restricted networks have the following additional limitations and restrictions:

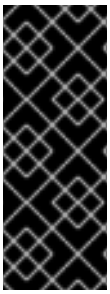
- The **ClusterVersion** status includes an **Unable to retrieve available updates** error.
- By default, you cannot use the contents of the Developer Catalog because you cannot access the required image stream tags.

8.12.3. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.11, you require access to the internet to obtain the images that are necessary to install your cluster.

You must have internet access to:

- Access OpenShift Cluster Manager Hybrid Cloud Console to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access Quay.io to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.



IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

8.12.4. Configuring your GCP project

Before you can install OpenShift Container Platform, you must configure a Google Cloud Platform (GCP) project to host it.

8.12.4.1. Creating a GCP project

To install OpenShift Container Platform, you must create a project in your Google Cloud Platform (GCP) account to host the cluster.

Procedure

- Create a project to host your OpenShift Container Platform cluster. See Creating and Managing Projects in the GCP documentation.

IMPORTANT

Your GCP project must use the Premium Network Service Tier if you are using installer-provisioned infrastructure. The Standard Network Service Tier is not supported for clusters installed using the installation program. The installation program configures internal load balancing for the **api-int.<cluster_name>.<base_domain>** URL; the Premium Tier is required for internal load balancing.

8.12.4.2. Enabling API services in GCP

Your Google Cloud Platform (GCP) project requires access to several API services to complete OpenShift Container Platform installation.

Prerequisites

- You created a project to host your cluster.

Procedure

- Enable the following required API services in the project that hosts your cluster. You may also enable optional API services which are not required for installation. See Enabling services in the GCP documentation.

Table 8.55. Required API services

API service	Console service name
Compute Engine API	**compute.googleapis.com**
Cloud Resource Manager API	**cloudresourcemanager.googleapis.com**
Google DNS API	**dns.googleapis.com**
IAM Service Account Credentials API	**iamcredentials.googleapis.com**
Identity and Access Management (IAM) API	**iam.googleapis.com**
Service Usage API	**serviceusage.googleapis.com**

Table 8.56. Optional API services

API service	Console service name
Google Cloud APIs	**cloudapis.googleapis.com**
Service Management API	**servicemanagement.googleapis.com**
Google Cloud Storage JSON API	**storage-api.googleapis.com**
Cloud Storage	**storage-component.googleapis.com**

8.12.4.3. Configuring DNS for GCP

To install OpenShift Container Platform, the Google Cloud Platform (GCP) account you use must have a dedicated public hosted zone in the same project that you host the OpenShift Container Platform cluster. This zone must be authoritative for the domain. The DNS service provides cluster DNS resolution and name lookup for external connections to the cluster.

Procedure

1. Identify your domain, or subdomain, and registrar. You can transfer an existing domain and registrar or obtain a new one through GCP or another source.

NOTE

If you purchase a new domain, it can take time for the relevant DNS changes to propagate. For more information about purchasing domains through Google, see Google Domains.

2. Create a public hosted zone for your domain or subdomain in your GCP project. See Creating public zones in the GCP documentation.
   Use an appropriate root domain, such as **openshiftcorp.com**, or subdomain, such as **clusters.openshiftcorp.com**.

3. Extract the new authoritative name servers from the hosted zone records. See Look up your Cloud DNS name servers in the GCP documentation.
   You typically have four name servers.

4. Update the registrar records for the name servers that your domain uses. For example, if you registered your domain to Google Domains, see the following topic in the Google Domains Help: How to switch to custom name servers .

5. If you migrated your root domain to Google Cloud DNS, migrate your DNS records. See Migrating to Cloud DNS in the GCP documentation.

6. If you use a subdomain, follow your company's procedures to add its delegation records to the parent domain. This process might include a request to your company's IT department or the division that controls the root domain and DNS services for your company.

8.12.4.4. GCP account limits

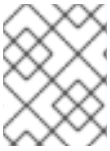
The OpenShift Container Platform cluster uses a number of Google Cloud Platform (GCP) components, but the default Quotas do not affect your ability to install a default OpenShift Container Platform cluster.

A default cluster, which contains three compute and three control plane machines, uses the following resources. Note that some resources are required only during the bootstrap process and are removed after the cluster deploys.

Table 8.57. GCP resources used in a default cluster

Service	Component	Location	Total resources required	Resources removed after bootstrap
Service account	IAM	Global	5	0
Firewall rules	Networking	Global	11	1
Forwarding rules	Compute	Global	2	0
Health checks	Compute	Global	2	0
Images	Compute	Global	1	0
Networks	Networking	Global	1	0

Service	Component	Location	Total resources required	Resources removed after bootstrap
Routers	Networking	Global	1	0
Routes	Networking	Global	2	0
Subnetworks	Compute	Global	2	0
Target pools	Networking	Global	2	0



NOTE

If any of the quotas are insufficient during installation, the installation program displays an error that states both which quota was exceeded and the region.

Be sure to consider your actual cluster size, planned cluster growth, and any usage from other clusters that are associated with your account. The CPU, static IP addresses, and persistent disk SSD (storage) quotas are the ones that are most likely to be insufficient.

If you plan to deploy your cluster in one of the following regions, you will exceed the maximum storage quota and are likely to exceed the CPU quota limit:

- **asia-east2**
- **asia-northeast2**
- **asia-south1**
- **australia-southeast1**
- **europe-north1**
- **europe-west2**
- **europe-west3**
- **europe-west6**
- **northamerica-northeast1**
- **southamerica-east1**
- **us-west2**

You can increase resource quotas from the GCP console, but you might need to file a support ticket. Be sure to plan your cluster size early so that you can allow time to resolve the support ticket before you install your OpenShift Container Platform cluster.

8.12.4.5. Creating a service account in GCP

OpenShift Container Platform requires a Google Cloud Platform (GCP) service account that provides authentication and authorization to access data in the Google APIs. If you do not have an existing IAM service account that contains the required roles in your project, you must create one.

Prerequisites

- You created a project to host your cluster.

Procedure

1. Create a service account in the project that you use to host your OpenShift Container Platform cluster. See Creating a service account in the GCP documentation.
2. Grant the service account the appropriate permissions. You can either grant the individual permissions that follow or assign the **Owner** role to it. See Granting roles to a service account for specific resources.

NOTE

While making the service account an owner of the project is the easiest way to gain the required permissions, it means that service account has complete control over the project. You must determine if the risk that comes from offering that power is acceptable.

3. Create the service account key in JSON format. See Creating service account keys in the GCP documentation.
   The service account key is required to create a cluster.

8.12.4.6. Required GCP roles

When you attach the **Owner** role to the service account that you create, you grant that service account all permissions, including those that are required to install OpenShift Container Platform. If your organization's security policies require a more restrictive set of permissions, you can create a service account with the following permissions. If you deploy your cluster into an existing virtual private cloud (VPC), the service account does not require certain networking permissions, which are noted in the following lists:

Required roles for the installation program

- Compute Admin
- Security Admin
- Service Account Admin
- Service Account Key Admin
- Service Account User
- Storage Admin

Required roles for creating network resources during installation

- DNS Administrator

Required roles for user-provisioned GCP infrastructure

- Deployment Manager Editor

The roles are applied to the service accounts that the control plane and compute machines use:

Table 8.58. GCP service account permissions

Account	Roles
Control Plane	**roles/compute.instanceAdmin**
	roles/compute.networkAdmin
	roles/compute.securityAdmin
	roles/storage.admin
	roles/iam.serviceAccountUser
Compute	**roles/compute.viewer**
	roles/storage.admin

8.12.4.7. Required GCP permissions for user-provisioned infrastructure

When you attach the **Owner** role to the service account that you create, you grant that service account all permissions, including those that are required to install OpenShift Container Platform.

If your organization's security policies require a more restrictive set of permissions, you can create custom roles with the necessary permissions. The following permissions are required for the user-provisioned infrastructure for creating and deleting the OpenShift Container Platform cluster.

Example 8.68. Required permissions for creating network resources

- **compute.addresses.create**
- **compute.addresses.createInternal**
- **compute.addresses.delete**
- **compute.addresses.get**
- **compute.addresses.list**
- **compute.addresses.use**
- **compute.addresses.useInternal**
- **compute.firewalls.create**
- **compute.firewalls.delete**

- **compute.firewalls.get**
- **compute.firewalls.list**
- **compute.forwardingRules.create**
- **compute.forwardingRules.get**
- **compute.forwardingRules.list**
- **compute.forwardingRules.setLabels**
- **compute.networks.create**
- **compute.networks.get**
- **compute.networks.list**
- **compute.networks.updatePolicy**
- **compute.routers.create**
- **compute.routers.get**
- **compute.routers.list**
- **compute.routers.update**
- **compute.routes.list**
- **compute.subnetworks.create**
- **compute.subnetworks.get**
- **compute.subnetworks.list**
- **compute.subnetworks.use**
- **compute.subnetworks.useExternalIp**

Example 8.69. Required permissions for creating load balancer resources

- **compute.regionBackendServices.create**
- **compute.regionBackendServices.get**
- **compute.regionBackendServices.list**
- **compute.regionBackendServices.update**
- **compute.regionBackendServices.use**
- **compute.targetPools.addInstance**
- **compute.targetPools.create**
- **compute.targetPools.get**

- **compute.targetPools.list**
- **compute.targetPools.removeInstance**
- **compute.targetPools.use**

Example 8.70. Required permissions for creating DNS resources

- **dns.changes.create**
- **dns.changes.get**
- **dns.managedZones.create**
- **dns.managedZones.get**
- **dns.managedZones.list**
- **dns.networks.bindPrivateDNSZone**
- **dns.resourceRecordSets.create**
- **dns.resourceRecordSets.list**
- **dns.resourceRecordSets.update**

Example 8.71. Required permissions for creating Service Account resources

- **iam.serviceAccountKeys.create**
- **iam.serviceAccountKeys.delete**
- **iam.serviceAccountKeys.get**
- **iam.serviceAccountKeys.list**
- **iam.serviceAccounts.actAs**
- **iam.serviceAccounts.create**
- **iam.serviceAccounts.delete**
- **iam.serviceAccounts.get**
- **iam.serviceAccounts.list**
- **resourcemanager.projects.get**
- **resourcemanager.projects.getIamPolicy**
- **resourcemanager.projects.setIamPolicy**

Example 8.72. Required permissions for creating compute resources

- **compute.disks.create**
- **compute.disks.get**
- **compute.disks.list**
- **compute.instanceGroups.create**
- **compute.instanceGroups.delete**
- **compute.instanceGroups.get**
- **compute.instanceGroups.list**
- **compute.instanceGroups.update**
- **compute.instanceGroups.use**
- **compute.instances.create**
- **compute.instances.delete**
- **compute.instances.get**
- **compute.instances.list**
- **compute.instances.setLabels**
- **compute.instances.setMetadata**
- **compute.instances.setServiceAccount**
- **compute.instances.setTags**
- **compute.instances.use**
- **compute.machineTypes.get**
- **compute.machineTypes.list**

Example 8.73. Required for creating storage resources

- **storage.buckets.create**
- **storage.buckets.delete**
- **storage.buckets.get**
- **storage.buckets.list**
- **storage.objects.create**
- **storage.objects.delete**
- **storage.objects.get**
- **storage.objects.list**

Example 8.74. Required permissions for creating health check resources

- **compute.healthChecks.create**
- **compute.healthChecks.get**
- **compute.healthChecks.list**
- **compute.healthChecks.useReadOnly**
- **compute.httpHealthChecks.create**
- **compute.httpHealthChecks.get**
- **compute.httpHealthChecks.list**
- **compute.httpHealthChecks.useReadOnly**

Example 8.75. Required permissions to get GCP zone and region related information

- **compute.globalOperations.get**
- **compute.regionOperations.get**
- **compute.regions.list**
- **compute.zoneOperations.get**
- **compute.zones.get**
- **compute.zones.list**

Example 8.76. Required permissions for checking services and quotas

- **monitoring.timeSeries.list**
- **serviceusage.quotas.get**
- **serviceusage.services.list**

Example 8.77. Required IAM permissions for installation

- **iam.roles.get**

Example 8.78. Required Images permissions for installation

- **compute.images.create**
- **compute.images.delete**

- **compute.images.get**
- **compute.images.list**

Example 8.79. Optional permission for running gather bootstrap

- **compute.instances.getSerialPortOutput**

Example 8.80. Required permissions for deleting network resources

- **compute.addresses.delete**
- **compute.addresses.deleteInternal**
- **compute.addresses.list**
- **compute.firewalls.delete**
- **compute.firewalls.list**
- **compute.forwardingRules.delete**
- **compute.forwardingRules.list**
- **compute.networks.delete**
- **compute.networks.list**
- **compute.networks.updatePolicy**
- **compute.routers.delete**
- **compute.routers.list**
- **compute.routes.list**
- **compute.subnetworks.delete**
- **compute.subnetworks.list**

Example 8.81. Required permissions for deleting load balancer resources

- **compute.regionBackendServices.delete**
- **compute.regionBackendServices.list**
- **compute.targetPools.delete**
- **compute.targetPools.list**

Example 8.82. Required permissions for deleting DNS resources

- **dns.changes.create**
- **dns.managedZones.delete**
- **dns.managedZones.get**
- **dns.managedZones.list**
- **dns.resourceRecordSets.delete**
- **dns.resourceRecordSets.list**

Example 8.83. Required permissions for deleting Service Account resources

- **iam.serviceAccounts.delete**
- **iam.serviceAccounts.get**
- **iam.serviceAccounts.list**
- **resourcemanager.projects.getIamPolicy**
- **resourcemanager.projects.setIamPolicy**

Example 8.84. Required permissions for deleting compute resources

- **compute.disks.delete**
- **compute.disks.list**
- **compute.instanceGroups.delete**
- **compute.instanceGroups.list**
- **compute.instances.delete**
- **compute.instances.list**
- **compute.instances.stop**
- **compute.machineTypes.list**

Example 8.85. Required for deleting storage resources

- **storage.buckets.delete**
- **storage.buckets.getIamPolicy**
- **storage.buckets.list**
- **storage.objects.delete**
- **storage.objects.list**

Example 8.86. Required permissions for deleting health check resources

- **compute.healthChecks.delete**
- **compute.healthChecks.list**
- **compute.httpHealthChecks.delete**
- **compute.httpHealthChecks.list**

Example 8.87. Required Images permissions for deletion

- **compute.images.delete**
- **compute.images.list**

Example 8.88. Required permissions to get Region related information

- **compute.regions.get**

Example 8.89. Required Deployment Manager permissions

- **deploymentmanager.deployments.create**
- **deploymentmanager.deployments.delete**
- **deploymentmanager.deployments.get**
- **deploymentmanager.deployments.list**
- **deploymentmanager.manifests.get**
- **deploymentmanager.operations.get**
- **deploymentmanager.resources.list**

Additional resources

- Optimizing storage

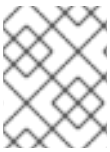
8.12.4.8. Supported GCP regions

You can deploy an OpenShift Container Platform cluster to the following Google Cloud Platform (GCP) regions:

- **asia-east1** (Changhua County, Taiwan)
- **asia-east2** (Hong Kong)
- **asia-northeast1** (Tokyo, Japan)

- **asia-northeast2** (Osaka, Japan)
- **asia-northeast3** (Seoul, South Korea)
- **asia-south1** (Mumbai, India)
- **asia-south2** (Delhi, India)
- **asia-southeast1** (Jurong West, Singapore)
- **asia-southeast2** (Jakarta, Indonesia)
- **australia-southeast1** (Sydney, Australia)
- **australia-southeast2** (Melbourne, Australia)
- **europe-central2** (Warsaw, Poland)
- **europe-north1** (Hamina, Finland)
- **europe-southwest1** (Madrid, Spain)
- **europe-west1** (St. Ghislain, Belgium)
- **europe-west2** (London, England, UK)
- **europe-west3** (Frankfurt, Germany)
- **europe-west4** (Eemshaven, Netherlands)
- **europe-west6** (Zürich, Switzerland)
- **europe-west8** (Milan, Italy)
- **europe-west9** (Paris, France)
- **europe-west12** (Turin, Italy)
- **northamerica-northeast1** (Montréal, Québec, Canada)
- **northamerica-northeast2** (Toronto, Ontario, Canada)
- **southamerica-east1** (São Paulo, Brazil)
- **southamerica-west1** (Santiago, Chile)
- **us-central1** (Council Bluffs, Iowa, USA)
- **us-east1** (Moncks Corner, South Carolina, USA)
- **us-east4** (Ashburn, Northern Virginia, USA)
- **us-east5** (Columbus, Ohio)
- **us-south1** (Dallas, Texas)
- **us-west1** (The Dalles, Oregon, USA)

- **us-west2** (Los Angeles, California, USA)
- **us-west3** (Salt Lake City, Utah, USA)
- **us-west4** (Las Vegas, Nevada, USA)



NOTE

To determine which machine type instances are available by region and zone, see the Google documentation.

8.12.4.9. Installing and configuring CLI tools for GCP

To install OpenShift Container Platform on Google Cloud Platform (GCP) using user-provisioned infrastructure, you must install and configure the CLI tools for GCP.

Prerequisites

- You created a project to host your cluster.
- You created a service account and granted it the required permissions.

Procedure

1. Install the following binaries in **$PATH**:
   - **gcloud**
   - **gsutil**

   See Install the latest Cloud SDK version in the GCP documentation.
2. Authenticate using the **gcloud** tool with your configured service account.
   See Authorizing with a service account in the GCP documentation.

8.12.5. Requirements for a cluster with user-provisioned infrastructure

For a cluster that contains user-provisioned infrastructure, you must deploy all of the required machines.

This section describes the requirements for deploying OpenShift Container Platform on user-provisioned infrastructure.

8.12.5.1. Required machines for cluster installation

The smallest OpenShift Container Platform clusters require the following hosts:

Table 8.59. Minimum required hosts

Hosts	Description
One temporary bootstrap machine	The cluster requires the bootstrap machine to deploy the OpenShift Container Platform cluster on the three control plane machines. You can remove the bootstrap machine after you install the cluster.

Hosts	Description
Three control plane machines	The control plane machines run the Kubernetes and OpenShift Container Platform services that form the control plane.
At least two compute machines, which are also known as worker machines.	The workloads requested by OpenShift Container Platform users run on the compute machines.

IMPORTANT

To maintain high availability of your cluster, use separate physical hosts for these cluster machines.

The bootstrap and control plane machines must use Red Hat Enterprise Linux CoreOS (RHCOS) as the operating system. However, the compute machines can choose between Red Hat Enterprise Linux CoreOS (RHCOS), Red Hat Enterprise Linux (RHEL) 8.6 and later.

Note that RHCOS is based on Red Hat Enterprise Linux (RHEL) 8 and inherits all of its hardware certifications and requirements. See Red Hat Enterprise Linux technology capabilities and limits .

8.12.5.2. Minimum resource requirements for cluster installation

Each cluster machine must meet the following minimum requirements:

Table 8.60. Minimum resource requirements

Machine	Operating System	vCPU [1]	Virtual RAM	Storage	IOPS [2]
Bootstrap	RHCOS	4	16 GB	100 GB	300
Control plane	RHCOS	4	16 GB	100 GB	300
Compute	RHCOS, RHEL 8.6 and later [3]	2	8 GB	100 GB	300

1. One vCPU is equivalent to one physical core when simultaneous multithreading (SMT), or hyperthreading, is not enabled. When enabled, use the following formula to calculate the corresponding ratio: (threads per core × cores) × sockets = vCPUs.

2. OpenShift Container Platform and Kubernetes are sensitive to disk performance, and faster storage is recommended, particularly for etcd on the control plane nodes which require a 10 ms p99 fsync duration. Note that on many cloud platforms, storage size and IOPS scale together, so you might need to over-allocate storage volume to obtain sufficient performance.

3. As with all user-provisioned installations, if you choose to use RHEL compute machines in your cluster, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks.

Use of RHEL 7 compute machines is deprecated and has been removed in OpenShift Container Platform 4.10 and later.

If an instance type for your platform meets the minimum requirements for cluster machines, it is supported to use in OpenShift Container Platform.

8.12.5.3. Tested instance types for GCP

The following Google Cloud Platform instance types have been tested with OpenShift Container Platform.

Example 8.90. Machine series

- **C2**
- **C2D**
- **C3**
- **E2**
- **M1**
- **N1**
- **N2**
- **N2D**
- **Tau T2D**

8.12.5.4. Using custom machine types

Using a custom machine type to install a OpenShift Container Platform cluster is supported.

Consider the following when using a custom machine type:

- Similar to predefined instance types, custom machine types must meet the minimum resource requirements for control plane and compute machines. For more information, see "Minimum resource requirements for cluster installation".
- The name of the custom machine type must adhere to the following syntax:
  custom-<number_of_cpus>-<amount_of_memory_in_mb>

  For example, **custom-6-20480**.

8.12.6. Creating the installation files for GCP

To install OpenShift Container Platform on Google Cloud Platform (GCP) using user-provisioned infrastructure, you must generate the files that the installation program needs to deploy your cluster and modify them so that the cluster creates only the machines that it will use. You generate and customize the **install-config.yaml** file, Kubernetes manifests, and Ignition config files. You also have the option to first set up a separate **var** partition during the preparation phases of installation.

8.12.6.1. Optional: Creating a separate /var partition

It is recommended that disk partitioning for OpenShift Container Platform be left to the installer. However, there are cases where you might want to create separate partitions in a part of the filesystem that you expect to grow.

OpenShift Container Platform supports the addition of a single partition to attach storage to either the **/var** partition or a subdirectory of **/var**. For example:

- **/var/lib/containers**: Holds container-related content that can grow as more images and containers are added to a system.
- **/var/lib/etcd**: Holds data that you might want to keep separate for purposes such as performance optimization of etcd storage.
- **/var**: Holds data that you might want to keep separate for purposes such as auditing.

Storing the contents of a **/var** directory separately makes it easier to grow storage for those areas as needed and reinstall OpenShift Container Platform at a later date and keep that data intact. With this method, you will not have to pull all your containers again, nor will you have to copy massive log files when you update systems.

Because **/var** must be in place before a fresh installation of Red Hat Enterprise Linux CoreOS (RHCOS), the following procedure sets up the separate **/var** partition by creating a machine config manifest that is inserted during the **openshift-install** preparation phases of an OpenShift Container Platform installation.

IMPORTANT

If you follow the steps to create a separate **/var** partition in this procedure, it is not necessary to create the Kubernetes manifest and Ignition config files again as described later in this section.

Procedure

1. Create a directory to hold the OpenShift Container Platform installation files:

```
$ mkdir $HOME/clusterconfig
```

2. Run **openshift-install** to create a set of files in the **manifest** and **openshift** subdirectories. Answer the system questions as you are prompted:

```
$ openshift-install create manifests --dir $HOME/clusterconfig
```

Example output

```
? SSH Public Key ...
INFO Credentials loaded from the "myprofile" profile in file "/home/myuser/.aws/credentials"
INFO Consuming Install Config from target directory
INFO Manifests created in: $HOME/clusterconfig/manifests and
$HOME/clusterconfig/openshift
```

3. Optional: Confirm that the installation program created manifests in the **clusterconfig/openshift** directory:

```
$ ls $HOME/clusterconfig/openshift/
```

Example output

```
99_kubeadmin-password-secret.yaml
99_openshift-cluster-api_master-machines-0.yaml
99_openshift-cluster-api_master-machines-1.yaml
99_openshift-cluster-api_master-machines-2.yaml
...
```

4. Create a Butane config that configures the additional partition. For example, name the file **$HOME/clusterconfig/98-var-partition.bu**, change the disk device name to the name of the storage device on the **worker** systems, and set the storage size as appropriate. This example places the **/var** directory on a separate partition:

```
variant: openshift
version: 4.11.0
metadata:
  labels:
    machineconfiguration.openshift.io/role: worker
  name: 98-var-partition
storage:
  disks:
  - device: /dev/<device_name> 1
    partitions:
    - label: var
      start_mib: <partition_start_offset> 2
      size_mib: <partition_size> 3
  filesystems:
    - device: /dev/disk/by-partlabel/var
      path: /var
      format: xfs
      mount_options: [defaults, prjquota] 4
      with_mount_unit: true
```

1. The storage device name of the disk that you want to partition.
2. When adding a data partition to the boot disk, a minimum value of 25000 MiB (Mebibytes) is recommended. The root file system is automatically resized to fill all available space up to the specified offset. If no value is specified, or if the specified value is smaller than the recommended minimum, the resulting root file system will be too small, and future reinstalls of RHCOS might overwrite the beginning of the data partition.
3. The size of the data partition in mebibytes.
4. The **prjquota** mount option must be enabled for filesystems used for container storage.

NOTE

When creating a separate **/var** partition, you cannot use different instance types for worker nodes, if the different instance types do not have the same device name.

5. Create a manifest from the Butane config and save it to the **clusterconfig/openshift** directory. For example, run the following command:

```
$ butane $HOME/clusterconfig/98-var-partition.bu -o $HOME/clusterconfig/openshift/98-var-partition.yaml
```

6. Run **openshift-install** again to create Ignition configs from a set of files in the **manifest** and **openshift** subdirectories:

```
$ openshift-install create ignition-configs --dir $HOME/clusterconfig
$ ls $HOME/clusterconfig/
auth  bootstrap.ign  master.ign  metadata.json  worker.ign
```

Now you can use the Ignition config files as input to the installation procedures to install Red Hat Enterprise Linux CoreOS (RHCOS) systems.

8.12.6.2. Creating the installation configuration file

You can customize the OpenShift Container Platform cluster you install on Google Cloud Platform (GCP).

Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster. For a restricted network installation, these files are on your mirror host.
- Have the **imageContentSources** values that were generated during mirror registry creation.
- Obtain the contents of the certificate for your mirror registry.
- Obtain service principal permissions at the subscription level.

Procedure

1. Create the **install-config.yaml** file.

   a. Change to the directory that contains the installation program and run the following command:

```
$ ./openshift-install create install-config --dir <installation_directory> 1
```

   1 For **<installation_directory>**, specify the directory name to store the files that the installation program creates.

   When specifying the directory:

   - Verify that the directory has the **execute** permission. This permission is required to run Terraform binaries under the installation directory.
   - Use an empty directory. Some installation assets, such as bootstrap X.509 certificates, have short expiration intervals, therefore you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them

into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

b. At the prompts, provide the configuration details for your cloud:

i. Optional: Select an SSH key to use to access your cluster machines.

NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

ii. Select **gcp** as the platform to target.

iii. If you have not configured the service account key for your GCP account on your computer, you must obtain it from GCP and paste the contents of the file or enter the absolute path to the file.

iv. Select the project ID to provision the cluster in. The default value is specified by the service account that you configured.

v. Select the region to deploy the cluster to.

vi. Select the base domain to deploy the cluster to. The base domain corresponds to the public DNS zone that you created for your cluster.

vii. Enter a descriptive name for your cluster.

viii. Paste the pull secret from the Red Hat OpenShift Cluster Manager .

2. Edit the **install-config.yaml** file to give the additional information that is required for an installation in a restricted network.

a. Update the **pullSecret** value to contain the authentication information for your registry:

```
pullSecret: '{"auths":{"<mirror_host_name>:5000": {"auth": "<credentials>","email":
"you@example.com"}}}'
```

For **<mirror_host_name>**, specify the registry domain name that you specified in the certificate for your mirror registry, and for **<credentials>**, specify the base64-encoded user name and password for your mirror registry.

b. Add the **additionalTrustBundle** parameter and value.

```
additionalTrustBundle: |
  -----BEGIN CERTIFICATE-----

ZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZ
  -----END CERTIFICATE-----
```

The value must be the contents of the certificate file that you used for your mirror registry. The certificate file can be an existing, trusted certificate authority, or the self-signed certificate that you generated for the mirror registry.

c. Define the network and subnets for the VPC to install the cluster in under the parent **platform.gcp** field:

```
network: <existing_vpc>
controlPlaneSubnet: <control_plane_subnet>
computeSubnet: <compute_subnet>
```

For **platform.gcp.network**, specify the name for the existing Google VPC. For **platform.gcp.controlPlaneSubnet** and **platform.gcp.computeSubnet**, specify the existing subnets to deploy the control plane machines and compute machines, respectively.

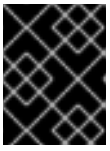
d. Add the image content resources, which resemble the following YAML excerpt:

```
imageContentSources:
- mirrors:
  - <mirror_host_name>:5000/<repo_name>/release
  source: quay.io/openshift-release-dev/ocp-release
- mirrors:
  - <mirror_host_name>:5000/<repo_name>/release
  source: registry.redhat.io/ocp/release
```

For these values, use the **imageContentSources** that you recorded during mirror registry creation.

3. Make any other modifications to the **install-config.yaml** file that you require. You can find more information about the available parameters in the **Installation configuration parameters** section.

4. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.



IMPORTANT

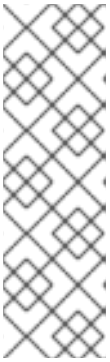
The **install-config.yaml** file is consumed during the installation process. If you want to reuse the file, you must back it up now.

8.12.6.3. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.



NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

Procedure

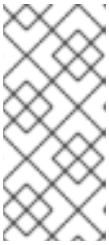
1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
```

1. A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
2. A proxy URL to use for creating HTTPS connections outside the cluster.
3. A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use ***** to bypass the proxy for all destinations.
4. If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace that contains one or more additional CA certificates that are required for proxying HTTPS connections. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges these contents with the Red Hat Enterprise Linux CoreOS (RHCOS) trust bundle, and this config map is referenced in the **trustedCA** field of the **Proxy** object. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.

NOTE

The installation program does not support the proxy **readinessEndpoints** field.



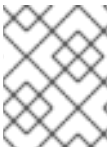
NOTE

If the installer times out, restart and then complete the deployment by using the **wait-for** command of the installer. For example:

```
$ ./openshift-install wait-for install-complete --log-level debug
```

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.



NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

8.12.6.4. Creating the Kubernetes manifest and Ignition config files

Because you must modify some cluster definition files and manually start the cluster machines, you must generate the Kubernetes manifest and Ignition config files that the cluster needs to configure the machines.

The installation configuration file transforms into the Kubernetes manifests. The manifests wrap into the Ignition configuration files, which are later used to configure the cluster machines.

IMPORTANT

- The Ignition config files that the OpenShift Container Platform installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

Prerequisites

- You obtained the OpenShift Container Platform installation program. For a restricted network installation, these files are on your mirror host.
- You created the **install-config.yaml** installation configuration file.

Procedure

1. Change to the directory that contains the OpenShift Container Platform installation program and generate the Kubernetes manifests for the cluster:

```
$ ./openshift-install create manifests --dir <installation_directory> 1
```

1 For **<installation_directory>**, specify the installation directory that contains the **install-config.yaml** file you created.

2. Remove the Kubernetes manifest files that define the control plane machines:

```
$ rm -f <installation_directory>/openshift/99_openshift-cluster-api_master-machines-*.yaml
```

By removing these files, you prevent the cluster from automatically generating control plane machines.

3. Optional: If you do not want the cluster to provision compute machines, remove the Kubernetes manifest files that define the worker machines:

```
$ rm -f <installation_directory>/openshift/99_openshift-cluster-api_worker-machineset-*.yaml
```

Because you create and manage the worker machines yourself, you do not need to initialize these machines.

4. Check that the **mastersSchedulable** parameter in the **<installation_directory>/manifests/cluster-scheduler-02-config.yml** Kubernetes manifest file is set to **false**. This setting prevents pods from being scheduled on the control plane machines:

   a. Open the **<installation_directory>/manifests/cluster-scheduler-02-config.yml** file.

   b. Locate the **mastersSchedulable** parameter and ensure that it is set to **false**.

   c. Save and exit the file.

5. Optional: If you do not want the Ingress Operator to create DNS records on your behalf, remove the **privateZone** and **publicZone** sections from the **<installation_directory>/manifests/cluster-dns-02-config.yml** DNS configuration file:

```
apiVersion: config.openshift.io/v1
kind: DNS
metadata:
  creationTimestamp: null
  name: cluster
spec:
  baseDomain: example.openshift.com
  privateZone: 1
    id: mycluster-100419-private-zone
  publicZone: 2
    id: example.openshift.com
status: {}
```

1 2 Remove this section completely.

If you do so, you must add ingress DNS records manually in a later step.

6. To create the Ignition configuration files, run the following command from the directory that contains the installation program:

```
$ ./openshift-install create ignition-configs --dir <installation_directory> 1
```

1 For **<installation_directory>**, specify the same installation directory.

Ignition config files are created for the bootstrap, control plane, and compute nodes in the installation directory. The **kubeadmin-password** and **kubeconfig** files are created in the **./<installation_directory>/auth** directory:

```
.
├── auth
│   ├── kubeadmin-password
│   └── kubeconfig
├── bootstrap.ign
├── master.ign
├── metadata.json
└── worker.ign
```

Additional resources

- Optional: Adding the ingress DNS records

8.12.7. Exporting common variables

8.12.7.1. Extracting the infrastructure name

The Ignition config files contain a unique cluster identifier that you can use to uniquely identify your cluster in Google Cloud Platform (GCP). The infrastructure name is also used to locate the appropriate GCP resources during an OpenShift Container Platform installation. The provided Deployment Manager templates contain references to this infrastructure name, so you must extract it.

Prerequisites

- You obtained the OpenShift Container Platform installation program and the pull secret for your cluster.
- You generated the Ignition config files for your cluster.
- You installed the **jq** package.

Procedure

- To extract and view the infrastructure name from the Ignition config file metadata, run the following command:

```
$ jq -r .infraID <installation_directory>/metadata.json 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

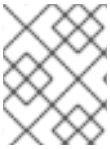
Example output

```
openshift-vw9j6 1
```

1 The output of this command is your cluster name and a random string.

8.12.7.2. Exporting common variables for Deployment Manager templates

You must export a common set of variables that are used with the provided Deployment Manager templates used to assist in completing a user-provided infrastructure install on Google Cloud Platform (GCP).



NOTE

Specific Deployment Manager templates can also require additional exported variables, which are detailed in their related procedures.

Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.
- Generate the Ignition config files for your cluster.
- Install the **jq** package.

Procedure

1. Export the following common variables to be used by the provided Deployment Manager templates:

```
$ export BASE_DOMAIN='<base_domain>'
$ export BASE_DOMAIN_ZONE_NAME='<base_domain_zone_name>'
$ export NETWORK_CIDR='10.0.0.0/16'
$ export MASTER_SUBNET_CIDR='10.0.0.0/17'
$ export WORKER_SUBNET_CIDR='10.0.128.0/17'

$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
$ export CLUSTER_NAME=`jq -r .clusterName <installation_directory>/metadata.json`
$ export INFRA_ID=`jq -r .infraID <installation_directory>/metadata.json`
$ export PROJECT_NAME=`jq -r .gcp.projectID <installation_directory>/metadata.json`
$ export REGION=`jq -r .gcp.region <installation_directory>/metadata.json`
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

8.12.8. Creating a VPC in GCP

You must create a VPC in Google Cloud Platform (GCP) for your OpenShift Container Platform cluster to use. You can customize the VPC to meet your requirements. One way to create the VPC is to modify the provided Deployment Manager template.

NOTE

If you do not use the provided Deployment Manager template to create your GCP infrastructure, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

Prerequisites

- Configure a GCP account.
- Generate the Ignition config files for your cluster.

Procedure

1. Copy the template from the **Deployment Manager template for the VPC**section of this topic and save it as **01_vpc.py** on your computer. This template describes the VPC that your cluster requires.
2. Create a **01_vpc.yaml** resource definition file:

```
$ cat <<EOF >01_vpc.yaml
imports:
- path: 01_vpc.py

resources:
- name: cluster-vpc
  type: 01_vpc.py
  properties:
    infra_id: '${INFRA_ID}' 1
    region: '${REGION}' 2
    master_subnet_cidr: '${MASTER_SUBNET_CIDR}' 3
    worker_subnet_cidr: '${WORKER_SUBNET_CIDR}' 4
EOF
```

1. **infra_id** is the **INFRA_ID** infrastructure name from the extraction step.
2. **region** is the region to deploy the cluster into, for example **us-central1**.
3. **master_subnet_cidr** is the CIDR for the master subnet, for example **10.0.0.0/17**.
4. **worker_subnet_cidr** is the CIDR for the worker subnet, for example **10.0.128.0/17**.

3. Create the deployment by using the **gcloud** CLI:

```
$ gcloud deployment-manager deployments create ${INFRA_ID}-vpc --config 01_vpc.yaml
```

8.12.8.1. Deployment Manager template for the VPC

You can use the following Deployment Manager template to deploy the VPC that you need for your OpenShift Container Platform cluster:

Example 8.91. 01_vpc.py Deployment Manager template

```
def GenerateConfig(context):

    resources = [{
        'name': context.properties['infra_id'] + '-network',
        'type': 'compute.v1.network',
        'properties': {
            'region': context.properties['region'],
            'autoCreateSubnetworks': False
        }
    }, {
        'name': context.properties['infra_id'] + '-master-subnet',
        'type': 'compute.v1.subnetwork',
        'properties': {
            'region': context.properties['region'],
            'network': '$(ref.' + context.properties['infra_id'] + '-network.selfLink)',
            'ipCidrRange': context.properties['master_subnet_cidr']
        }
    }, {
        'name': context.properties['infra_id'] + '-worker-subnet',
        'type': 'compute.v1.subnetwork',
        'properties': {
            'region': context.properties['region'],
            'network': '$(ref.' + context.properties['infra_id'] + '-network.selfLink)',
            'ipCidrRange': context.properties['worker_subnet_cidr']
        }
    }, {
        'name': context.properties['infra_id'] + '-router',
        'type': 'compute.v1.router',
        'properties': {
            'region': context.properties['region'],
            'network': '$(ref.' + context.properties['infra_id'] + '-network.selfLink)',
            'nats': [{
                'name': context.properties['infra_id'] + '-nat-master',
                'natIpAllocateOption': 'AUTO_ONLY',
                'minPortsPerVm': 7168,
                'sourceSubnetworkIpRangesToNat': 'LIST_OF_SUBNETWORKS',
                'subnetworks': [{
                    'name': '$(ref.' + context.properties['infra_id'] + '-master-subnet.selfLink)',
                    'sourceIpRangesToNat': ['ALL_IP_RANGES']
                }]
            }, {
                'name': context.properties['infra_id'] + '-nat-worker',
                'natIpAllocateOption': 'AUTO_ONLY',
                'minPortsPerVm': 512,
                'sourceSubnetworkIpRangesToNat': 'LIST_OF_SUBNETWORKS',
                'subnetworks': [{
                    'name': '$(ref.' + context.properties['infra_id'] + '-worker-subnet.selfLink)',
                    'sourceIpRangesToNat': ['ALL_IP_RANGES']
                }]
            }]
        }
    }]

    return {'resources': resources}
```

8.12.9. Networking requirements for user-provisioned infrastructure

All the Red Hat Enterprise Linux CoreOS (RHCOS) machines require networking to be configured in **initramfs** during boot to fetch their Ignition config files.

8.12.9.1. Setting the cluster node hostnames through DHCP

On Red Hat Enterprise Linux CoreOS (RHCOS) machines, the hostname is set through NetworkManager. By default, the machines obtain their hostname through DHCP. If the hostname is not provided by DHCP, set statically through kernel arguments, or another method, it is obtained through a reverse DNS lookup. Reverse DNS lookup occurs after the network has been initialized on a node and can take time to resolve. Other system services can start prior to this and detect the hostname as **localhost** or similar. You can avoid this by using DHCP to provide the hostname for each cluster node.

Additionally, setting the hostnames through DHCP can bypass any manual DNS record name configuration errors in environments that have a DNS split-horizon implementation.

8.12.9.2. Network connectivity requirements

You must configure the network connectivity between machines to allow OpenShift Container Platform cluster components to communicate. Each machine must be able to resolve the hostnames of all other machines in the cluster.

This section provides details about the ports that are required.

Table 8.61. Ports used for all-machine to all-machine communications

Protocol	Port	Description
ICMP	N/A	Network reachability tests
TCP	**1936**	Metrics
	9000-**9999**	Host level services, including the node exporter on ports **9100**-**9101** and the Cluster Version Operator on port**9099**.
	10250-**10259**	The default ports that Kubernetes reserves
	10256	openshift-sdn
UDP	**4789**	VXLAN
	6081	Geneve
	9000-**9999**	Host level services, including the node exporter on ports **9100**-**9101**.
	500	IPsec IKE packets
	4500	IPsec NAT-T packets

Protocol	Port	Description
TCP/UDP	**30000**-**32767**	Kubernetes node port
ESP	N/A	IPsec Encapsulating Security Payload (ESP)

Table 8.62. Ports used for all-machine to control plane communications

Protocol	Port	Description
TCP	**6443**	Kubernetes API

Table 8.63. Ports used for control plane machine to control plane machine communications

Protocol	Port	Description
TCP	**2379**-**2380**	etcd server and peer ports

8.12.10. Creating load balancers in GCP

You must configure load balancers in Google Cloud Platform (GCP) for your OpenShift Container Platform cluster to use. One way to create these components is to modify the provided Deployment Manager template.

NOTE

If you do not use the provided Deployment Manager template to create your GCP infrastructure, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

Prerequisites

- Configure a GCP account.
- Generate the Ignition config files for your cluster.
- Create and configure a VPC and associated subnets in GCP.

Procedure

1. Copy the template from the **Deployment Manager template for the internal load balancer** section of this topic and save it as **02_lb_int.py** on your computer. This template describes the internal load balancing objects that your cluster requires.
2. For an external cluster, also copy the template from the **Deployment Manager template for the external load balancer** section of this topic and save it as **02_lb_ext.py** on your computer. This template describes the external load balancing objects that your cluster requires.
3. Export the variables that the deployment template uses:

a. Export the cluster network location:

```
$ export CLUSTER_NETWORK=(`gcloud compute networks describe ${INFRA_ID}-network --format json | jq -r .selfLink`)
```

b. Export the control plane subnet location:

```
$ export CONTROL_SUBNET=(`gcloud compute networks subnets describe ${INFRA_ID}-master-subnet --region=${REGION} --format json | jq -r .selfLink`)
```

c. Export the three zones that the cluster uses:

```
$ export ZONE_0=(`gcloud compute regions describe ${REGION} --format=json | jq -r .zones[0] | cut -d "/" -f9`)
```

```
$ export ZONE_1=(`gcloud compute regions describe ${REGION} --format=json | jq -r .zones[1] | cut -d "/" -f9`)
```

```
$ export ZONE_2=(`gcloud compute regions describe ${REGION} --format=json | jq -r .zones[2] | cut -d "/" -f9`)
```

4. Create a **02_infra.yaml** resource definition file:

```
$ cat <<EOF >02_infra.yaml
imports:
- path: 02_lb_ext.py
- path: 02_lb_int.py (1)
resources:
- name: cluster-lb-ext (2)
  type: 02_lb_ext.py
  properties:
    infra_id: '${INFRA_ID}' (3)
    region: '${REGION}' (4)
- name: cluster-lb-int
  type: 02_lb_int.py
  properties:
    cluster_network: '${CLUSTER_NETWORK}'
    control_subnet: '${CONTROL_SUBNET}' (5)
    infra_id: '${INFRA_ID}'
    region: '${REGION}'
    zones: (6)
    - '${ZONE_0}'
    - '${ZONE_1}'
    - '${ZONE_2}'
EOF
```

(1) (2) Required only when deploying an external cluster.

(3) **infra_id** is the **INFRA_ID** infrastructure name from the extraction step.

(4) **region** is the region to deploy the cluster into, for example **us-central1**.

(5) **control_subnet** is the URI to the control subnet.

6 **zones** are the zones to deploy the control plane instances into, like **us-east1-b**, **us-east1-c**, and **us-east1-d**.

5. Create the deployment by using the **gcloud** CLI:

```
$ gcloud deployment-manager deployments create ${INFRA_ID}-infra --config 02_infra.yaml
```

6. Export the cluster IP address:

```
$ export CLUSTER_IP=(`gcloud compute addresses describe ${INFRA_ID}-cluster-ip --
region=${REGION} --format json | jq -r .address`)
```

7. For an external cluster, also export the cluster public IP address:

```
$ export CLUSTER_PUBLIC_IP=(`gcloud compute addresses describe ${INFRA_ID}-cluster-
public-ip --region=${REGION} --format json | jq -r .address`)
```

8.12.10.1. Deployment Manager template for the external load balancer

You can use the following Deployment Manager template to deploy the external load balancer that you need for your OpenShift Container Platform cluster:

Example 8.92. 02_lb_ext.py Deployment Manager template

```
def GenerateConfig(context):

    resources = [{
        'name': context.properties['infra_id'] + '-cluster-public-ip',
        'type': 'compute.v1.address',
        'properties': {
            'region': context.properties['region']
        }
    }, {
        # Refer to docs/dev/kube-apiserver-health-check.md on how to correctly setup health check
probe for kube-apiserver
        'name': context.properties['infra_id'] + '-api-http-health-check',
        'type': 'compute.v1.httpHealthCheck',
        'properties': {
            'port': 6080,
            'requestPath': '/readyz'
        }
    }, {
        'name': context.properties['infra_id'] + '-api-target-pool',
        'type': 'compute.v1.targetPool',
        'properties': {
            'region': context.properties['region'],
            'healthChecks': ['$(ref.' + context.properties['infra_id'] + '-api-http-health-check.selfLink)'],
            'instances': []
        }
    }, {
        'name': context.properties['infra_id'] + '-api-forwarding-rule',
        'type': 'compute.v1.forwardingRule',
        'properties': {
```

```
            'region': context.properties['region'],
            'IPAddress': '$(ref.' + context.properties['infra_id'] + '-cluster-public-ip.selfLink)',
            'target': '$(ref.' + context.properties['infra_id'] + '-api-target-pool.selfLink)',
            'portRange': '6443'
        }
    }]

    return {'resources': resources}
```

8.12.10.2. Deployment Manager template for the internal load balancer

You can use the following Deployment Manager template to deploy the internal load balancer that you need for your OpenShift Container Platform cluster:

Example 8.93. 02_lb_int.py Deployment Manager template

```
def GenerateConfig(context):

    backends = []
    for zone in context.properties['zones']:
        backends.append({
            'group': '$(ref.' + context.properties['infra_id'] + '-master-' + zone + '-ig' + '.selfLink)'
        })

    resources = [{
        'name': context.properties['infra_id'] + '-cluster-ip',
        'type': 'compute.v1.address',
        'properties': {
            'addressType': 'INTERNAL',
            'region': context.properties['region'],
            'subnetwork': context.properties['control_subnet']
        }
    }, {
        # Refer to docs/dev/kube-apiserver-health-check.md on how to correctly setup health check
probe for kube-apiserver
        'name': context.properties['infra_id'] + '-api-internal-health-check',
        'type': 'compute.v1.healthCheck',
        'properties': {
            'httpsHealthCheck': {
                'port': 6443,
                'requestPath': '/readyz'
            },
            'type': "HTTPS"
        }
    }, {
        'name': context.properties['infra_id'] + '-api-internal-backend-service',
        'type': 'compute.v1.regionBackendService',
        'properties': {
            'backends': backends,
            'healthChecks': ['$(ref.' + context.properties['infra_id'] + '-api-internal-health-
check.selfLink)'],
            'loadBalancingScheme': 'INTERNAL',
            'region': context.properties['region'],
            'protocol': 'TCP',
```

```
            'timeoutSec': 120
        }
    }, {
        'name': context.properties['infra_id'] + '-api-internal-forwarding-rule',
        'type': 'compute.v1.forwardingRule',
        'properties': {
            'backendService': '$(ref.' + context.properties['infra_id'] + '-api-internal-backend-
service.selfLink)',
            'IPAddress': '$(ref.' + context.properties['infra_id'] + '-cluster-ip.selfLink)',
            'loadBalancingScheme': 'INTERNAL',
            'ports': ['6443','22623'],
            'region': context.properties['region'],
            'subnetwork': context.properties['control_subnet']
        }
    }]

    for zone in context.properties['zones']:
        resources.append({
            'name': context.properties['infra_id'] + '-master-' + zone + '-ig',
            'type': 'compute.v1.instanceGroup',
            'properties': {
                'namedPorts': [
                    {
                        'name': 'ignition',
                        'port': 22623
                    }, {
                        'name': 'https',
                        'port': 6443
                    }
                ],
                'network': context.properties['cluster_network'],
                'zone': zone
            }
        })

    return {'resources': resources}
```

You will need this template in addition to the **02_lb_ext.py** template when you create an external cluster.

8.12.11. Creating a private DNS zone in GCP

You must configure a private DNS zone in Google Cloud Platform (GCP) for your OpenShift Container Platform cluster to use. One way to create this component is to modify the provided Deployment Manager template.

NOTE

If you do not use the provided Deployment Manager template to create your GCP infrastructure, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

Prerequisites

- Configure a GCP account.
- Generate the Ignition config files for your cluster.
- Create and configure a VPC and associated subnets in GCP.

Procedure

1. Copy the template from the **Deployment Manager template for the private DNS**section of this topic and save it as **02_dns.py** on your computer. This template describes the private DNS objects that your cluster requires.
2. Create a **02_dns.yaml** resource definition file:

```
$ cat <<EOF >02_dns.yaml
imports:
- path: 02_dns.py

resources:
- name: cluster-dns
  type: 02_dns.py
  properties:
    infra_id: '${INFRA_ID}' 1
    cluster_domain: '${CLUSTER_NAME}.${BASE_DOMAIN}' 2
    cluster_network: '${CLUSTER_NETWORK}' 3
EOF
```

1. **infra_id** is the **INFRA_ID** infrastructure name from the extraction step.
2. **cluster_domain** is the domain for the cluster, for example **openshift.example.com**.
3. **cluster_network** is the **selfLink** URL to the cluster network.

3. Create the deployment by using the **gcloud** CLI:

```
$ gcloud deployment-manager deployments create ${INFRA_ID}-dns --config 02_dns.yaml
```

4. The templates do not create DNS entries due to limitations of Deployment Manager, so you must create them manually:
   a. Add the internal DNS entries:

```
$ if [ -f transaction.yaml ]; then rm transaction.yaml; fi
$ gcloud dns record-sets transaction start --zone ${INFRA_ID}-private-zone
$ gcloud dns record-sets transaction add ${CLUSTER_IP} --name
api.${CLUSTER_NAME}.${BASE_DOMAIN}. --ttl 60 --type A --zone ${INFRA_ID}-
private-zone
$ gcloud dns record-sets transaction add ${CLUSTER_IP} --name api-
int.${CLUSTER_NAME}.${BASE_DOMAIN}. --ttl 60 --type A --zone ${INFRA_ID}-
private-zone
$ gcloud dns record-sets transaction execute --zone ${INFRA_ID}-private-zone
```

b. For an external cluster, also add the external DNS entries:

```
$ if [ -f transaction.yaml ]; then rm transaction.yaml; fi
$ gcloud dns record-sets transaction start --zone ${BASE_DOMAIN_ZONE_NAME}
$ gcloud dns record-sets transaction add ${CLUSTER_PUBLIC_IP} --name
api.${CLUSTER_NAME}.${BASE_DOMAIN}. --ttl 60 --type A --zone
${BASE_DOMAIN_ZONE_NAME}
$ gcloud dns record-sets transaction execute --zone ${BASE_DOMAIN_ZONE_NAME}
```

8.12.11.1. Deployment Manager template for the private DNS

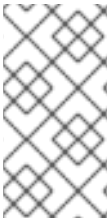
You can use the following Deployment Manager template to deploy the private DNS that you need for your OpenShift Container Platform cluster:

Example 8.94. 02_dns.py Deployment Manager template

```
def GenerateConfig(context):

    resources = [{
        'name': context.properties['infra_id'] + '-private-zone',
        'type': 'dns.v1.managedZone',
        'properties': {
            'description': '',
            'dnsName': context.properties['cluster_domain'] + '.',
            'visibility': 'private',
            'privateVisibilityConfig': {
                'networks': [{
                    'networkUrl': context.properties['cluster_network']
                }]
            }
        }
    }]

    return {'resources': resources}
```

8.12.12. Creating firewall rules in GCP

You must create firewall rules in Google Cloud Platform (GCP) for your OpenShift Container Platform cluster to use. One way to create these components is to modify the provided Deployment Manager template.



NOTE

If you do not use the provided Deployment Manager template to create your GCP infrastructure, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

Prerequisites

- Configure a GCP account.

- Generate the Ignition config files for your cluster.
- Create and configure a VPC and associated subnets in GCP.

Procedure

1. Copy the template from the **Deployment Manager template for firewall rules**section of this topic and save it as **03_firewall.py** on your computer. This template describes the security groups that your cluster requires.
2. Create a **03_firewall.yaml** resource definition file:

```
$ cat <<EOF >03_firewall.yaml
imports:
- path: 03_firewall.py

resources:
- name: cluster-firewall
  type: 03_firewall.py
  properties:
    allowed_external_cidr: '0.0.0.0/0' 1
    infra_id: '${INFRA_ID}' 2
    cluster_network: '${CLUSTER_NETWORK}' 3
    network_cidr: '${NETWORK_CIDR}' 4
EOF
```

1. **allowed_external_cidr** is the CIDR range that can access the cluster API and SSH to the bootstrap host. For an internal cluster, set this value to **${NETWORK_CIDR}**.
2. **infra_id** is the **INFRA_ID** infrastructure name from the extraction step.
3. **cluster_network** is the **selfLink** URL to the cluster network.
4. **network_cidr** is the CIDR of the VPC network, for example **10.0.0.0/16**.

3. Create the deployment by using the **gcloud** CLI:

```
$ gcloud deployment-manager deployments create ${INFRA_ID}-firewall --config
03_firewall.yaml
```

8.12.12.1. Deployment Manager template for firewall rules

You can use the following Deployment Manager template to deploy the firewall rues that you need for your OpenShift Container Platform cluster:

Example 8.95. 03_firewall.py Deployment Manager template

```
def GenerateConfig(context):

    resources = [{
        'name': context.properties['infra_id'] + '-bootstrap-in-ssh',
        'type': 'compute.v1.firewall',
        'properties': {
```

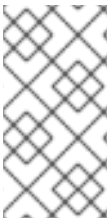
```
            'network': context.properties['cluster_network'],
            'allowed': [{
                'IPProtocol': 'tcp',
                'ports': ['22']
            }],
            'sourceRanges': [context.properties['allowed_external_cidr']],
            'targetTags': [context.properties['infra_id'] + '-bootstrap']
        }
    }, {
        'name': context.properties['infra_id'] + '-api',
        'type': 'compute.v1.firewall',
        'properties': {
            'network': context.properties['cluster_network'],
            'allowed': [{
                'IPProtocol': 'tcp',
                'ports': ['6443']
            }],
            'sourceRanges': [context.properties['allowed_external_cidr']],
            'targetTags': [context.properties['infra_id'] + '-master']
        }
    }, {
        'name': context.properties['infra_id'] + '-health-checks',
        'type': 'compute.v1.firewall',
        'properties': {
            'network': context.properties['cluster_network'],
            'allowed': [{
                'IPProtocol': 'tcp',
                'ports': ['6080', '6443', '22624']
            }],
            'sourceRanges': ['35.191.0.0/16', '130.211.0.0/22', '209.85.152.0/22', '209.85.204.0/22'],
            'targetTags': [context.properties['infra_id'] + '-master']
        }
    }, {
        'name': context.properties['infra_id'] + '-etcd',
        'type': 'compute.v1.firewall',
        'properties': {
            'network': context.properties['cluster_network'],
            'allowed': [{
                'IPProtocol': 'tcp',
                'ports': ['2379-2380']
            }],
            'sourceTags': [context.properties['infra_id'] + '-master'],
            'targetTags': [context.properties['infra_id'] + '-master']
        }
    }, {
        'name': context.properties['infra_id'] + '-control-plane',
        'type': 'compute.v1.firewall',
        'properties': {
            'network': context.properties['cluster_network'],
            'allowed': [{
                'IPProtocol': 'tcp',
                'ports': ['10257']
            },{
                'IPProtocol': 'tcp',
                'ports': ['10259']
            },{
```

```
                'IPProtocol': 'tcp',
                'ports': ['22623']
            }],
            'sourceTags': [
                context.properties['infra_id'] + '-master',
                context.properties['infra_id'] + '-worker'
            ],
            'targetTags': [context.properties['infra_id'] + '-master']
        }
    }, {
        'name': context.properties['infra_id'] + '-internal-network',
        'type': 'compute.v1.firewall',
        'properties': {
            'network': context.properties['cluster_network'],
            'allowed': [{
                'IPProtocol': 'icmp'
            },{
                'IPProtocol': 'tcp',
                'ports': ['22']
            }],
            'sourceRanges': [context.properties['network_cidr']],
            'targetTags': [
                context.properties['infra_id'] + '-master',
                context.properties['infra_id'] + '-worker'
            ]
        }
    }, {
        'name': context.properties['infra_id'] + '-internal-cluster',
        'type': 'compute.v1.firewall',
        'properties': {
            'network': context.properties['cluster_network'],
            'allowed': [{
                'IPProtocol': 'udp',
                'ports': ['4789', '6081']
            },{
                'IPProtocol': 'udp',
                'ports': ['500', '4500']
            },{
                'IPProtocol': 'esp',
            },{
                'IPProtocol': 'tcp',
                'ports': ['9000-9999']
            },{
                'IPProtocol': 'udp',
                'ports': ['9000-9999']
            },{
                'IPProtocol': 'tcp',
                'ports': ['10250']
            },{
                'IPProtocol': 'tcp',
                'ports': ['30000-32767']
            },{
                'IPProtocol': 'udp',
                'ports': ['30000-32767']
            }],
            'sourceTags': [
```

```
            context.properties['infra_id'] + '-master',
            context.properties['infra_id'] + '-worker'
        ],
        'targetTags': [
            context.properties['infra_id'] + '-master',
            context.properties['infra_id'] + '-worker'
        ]
    }
}]

return {'resources': resources}
```

8.12.13. Creating IAM roles in GCP

You must create IAM roles in Google Cloud Platform (GCP) for your OpenShift Container Platform cluster to use. One way to create these components is to modify the provided Deployment Manager template.



NOTE

If you do not use the provided Deployment Manager template to create your GCP infrastructure, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

Prerequisites

- Configure a GCP account.
- Generate the Ignition config files for your cluster.
- Create and configure a VPC and associated subnets in GCP.

Procedure

1. Copy the template from the **Deployment Manager template for IAM roles**section of this topic and save it as **03_iam.py** on your computer. This template describes the IAM roles that your cluster requires.
2. Create a **03_iam.yaml** resource definition file:

```
$ cat <<EOF >03_iam.yaml
imports:
- path: 03_iam.py
resources:
- name: cluster-iam
  type: 03_iam.py
  properties:
    infra_id: '${INFRA_ID}' (1)
EOF
```

(1) **infra_id** is the **INFRA_ID** infrastructure name from the extraction step.

3. Create the deployment by using the **gcloud** CLI:

```
$ gcloud deployment-manager deployments create ${INFRA_ID}-iam --config 03_iam.yaml
```

4. Export the variable for the master service account:

```
$ export MASTER_SERVICE_ACCOUNT=(`gcloud iam service-accounts list --filter
"email~^${INFRA_ID}-m@${PROJECT_NAME}." --format json | jq -r '.[0].email'`)
```

5. Export the variable for the worker service account:

```
$ export WORKER_SERVICE_ACCOUNT=(`gcloud iam service-accounts list --filter
"email~^${INFRA_ID}-w@${PROJECT_NAME}." --format json | jq -r '.[0].email'`)
```

6. Export the variable for the subnet that hosts the compute machines:

```
$ export COMPUTE_SUBNET=(`gcloud compute networks subnets describe ${INFRA_ID}-
worker-subnet --region=${REGION} --format json | jq -r .selfLink`)
```

7. The templates do not create the policy bindings due to limitations of Deployment Manager, so you must create them manually:

```
$ gcloud projects add-iam-policy-binding ${PROJECT_NAME} --member
"serviceAccount:${MASTER_SERVICE_ACCOUNT}" --role "roles/compute.instanceAdmin"
$ gcloud projects add-iam-policy-binding ${PROJECT_NAME} --member
"serviceAccount:${MASTER_SERVICE_ACCOUNT}" --role "roles/compute.networkAdmin"
$ gcloud projects add-iam-policy-binding ${PROJECT_NAME} --member
"serviceAccount:${MASTER_SERVICE_ACCOUNT}" --role "roles/compute.securityAdmin"
$ gcloud projects add-iam-policy-binding ${PROJECT_NAME} --member
"serviceAccount:${MASTER_SERVICE_ACCOUNT}" --role "roles/iam.serviceAccountUser"
$ gcloud projects add-iam-policy-binding ${PROJECT_NAME} --member
"serviceAccount:${MASTER_SERVICE_ACCOUNT}" --role "roles/storage.admin"

$ gcloud projects add-iam-policy-binding ${PROJECT_NAME} --member
"serviceAccount:${WORKER_SERVICE_ACCOUNT}" --role "roles/compute.viewer"
$ gcloud projects add-iam-policy-binding ${PROJECT_NAME} --member
"serviceAccount:${WORKER_SERVICE_ACCOUNT}" --role "roles/storage.admin"
```

8. Create a service account key and store it locally for later use:

```
$ gcloud iam service-accounts keys create service-account-key.json --iam-
account=${MASTER_SERVICE_ACCOUNT}
```

8.12.13.1. Deployment Manager template for IAM roles

You can use the following Deployment Manager template to deploy the IAM roles that you need for your OpenShift Container Platform cluster:

Example 8.96. 03_iam.py Deployment Manager template

```
def GenerateConfig(context):

  resources = [{
```

```
        'name': context.properties['infra_id'] + '-master-node-sa',
        'type': 'iam.v1.serviceAccount',
        'properties': {
            'accountId': context.properties['infra_id'] + '-m',
            'displayName': context.properties['infra_id'] + '-master-node'
        }
    }, {
        'name': context.properties['infra_id'] + '-worker-node-sa',
        'type': 'iam.v1.serviceAccount',
        'properties': {
            'accountId': context.properties['infra_id'] + '-w',
            'displayName': context.properties['infra_id'] + '-worker-node'
        }
    }]

    return {'resources': resources}
```

8.12.14. Creating the RHCOS cluster image for the GCP infrastructure

You must use a valid Red Hat Enterprise Linux CoreOS (RHCOS) image for Google Cloud Platform (GCP) for your OpenShift Container Platform nodes.

Procedure

1. Obtain the RHCOS image from the RHCOS image mirror page.

IMPORTANT

The RHCOS images might not change with every release of OpenShift Container Platform. You must download an image with the highest version that is less than or equal to the OpenShift Container Platform version that you install. Use the image version that matches your OpenShift Container Platform version if it is available.

The file name contains the OpenShift Container Platform version number in the format **rhcos-<version>-<arch>-gcp.<arch>.tar.gz**.

2. Create the Google storage bucket:

```
$ gsutil mb gs://<bucket_name>
```

3. Upload the RHCOS image to the Google storage bucket:

```
$ gsutil cp <downloaded_image_file_path>/rhcos-<version>-x86_64-gcp.x86_64.tar.gz
gs://<bucket_name>
```

4. Export the uploaded RHCOS image location as a variable:

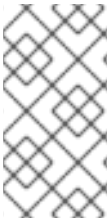
```
$ export IMAGE_SOURCE=gs://<bucket_name>/rhcos-<version>-x86_64-gcp.x86_64.tar.gz
```

5. Create the cluster image:

```
$ gcloud compute images create "${INFRA_ID}-rhcos-image" \
    --source-uri="${IMAGE_SOURCE}"
```

8.12.15. Creating the bootstrap machine in GCP

You must create the bootstrap machine in Google Cloud Platform (GCP) to use during OpenShift Container Platform cluster initialization. One way to create this machine is to modify the provided Deployment Manager template.



NOTE

If you do not use the provided Deployment Manager template to create your bootstrap machine, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

Prerequisites

- Configure a GCP account.
- Generate the Ignition config files for your cluster.
- Create and configure a VPC and associated subnets in GCP.
- Create and configure networking and load balancers in GCP.
- Create control plane and compute roles.
- Ensure pyOpenSSL is installed.

Procedure

1. Copy the template from the **Deployment Manager template for the bootstrap machine** section of this topic and save it as **04_bootstrap.py** on your computer. This template describes the bootstrap machine that your cluster requires.
2. Export the location of the Red Hat Enterprise Linux CoreOS (RHCOS) image that the installation program requires:

```
$ export CLUSTER_IMAGE=(`gcloud compute images describe ${INFRA_ID}-rhcos-image --format json | jq -r .selfLink`)
```

3. Create a bucket and upload the **bootstrap.ign** file:

```
$ gsutil mb gs://${INFRA_ID}-bootstrap-ignition
```

```
$ gsutil cp <installation_directory>/bootstrap.ign gs://${INFRA_ID}-bootstrap-ignition/
```

4. Create a signed URL for the bootstrap instance to use to access the Ignition config. Export the URL from the output as a variable:

```
$ export BOOTSTRAP_IGN=`gsutil signurl -d 1h service-account-key.json gs://${INFRA_ID}-bootstrap-ignition/bootstrap.ign | grep "^gs:" | awk '{print $5}'`
```

5. Create a **04_bootstrap.yaml** resource definition file:

```
$ cat <<EOF >04_bootstrap.yaml
imports:
- path: 04_bootstrap.py

resources:
- name: cluster-bootstrap
  type: 04_bootstrap.py
  properties:
    infra_id: '${INFRA_ID}' (1)
    region: '${REGION}' (2)
    zone: '${ZONE_0}' (3)

    cluster_network: '${CLUSTER_NETWORK}' (4)
    control_subnet: '${CONTROL_SUBNET}' (5)
    image: '${CLUSTER_IMAGE}' (6)
    machine_type: 'n1-standard-4' (7)
    root_volume_size: '128' (8)

    bootstrap_ign: '${BOOTSTRAP_IGN}' (9)
EOF
```

(1) **infra_id** is the **INFRA_ID** infrastructure name from the extraction step.

(2) **region** is the region to deploy the cluster into, for example **us-central1**.

(3) **zone** is the zone to deploy the bootstrap instance into, for example **us-central1-b**.

(4) **cluster_network** is the **selfLink** URL to the cluster network.

(5) **control_subnet** is the **selfLink** URL to the control subnet.

(6) **image** is the **selfLink** URL to the RHCOS image.

(7) **machine_type** is the machine type of the instance, for example **n1-standard-4**.

(8) **root_volume_size** is the boot disk size for the bootstrap machine.

(9) **bootstrap_ign** is the URL output when creating a signed URL.

6. Create the deployment by using the **gcloud** CLI:

```
$ gcloud deployment-manager deployments create ${INFRA_ID}-bootstrap --config
04_bootstrap.yaml
```

7. The templates do not manage load balancer membership due to limitations of Deployment Manager, so you must add the bootstrap machine manually.

   a. Add the bootstrap instance to the internal load balancer instance group:

```
$ gcloud compute instance-groups unmanaged add-instances \
    ${INFRA_ID}-bootstrap-ig --zone=${ZONE_0} --instances=${INFRA_ID}-bootstrap
```

b. Add the bootstrap instance group to the internal load balancer backend service:

```
$ gcloud compute backend-services add-backend \
    ${INFRA_ID}-api-internal-backend-service --region=${REGION} --instance-
group=${INFRA_ID}-bootstrap-ig --instance-group-zone=${ZONE_0}
```

8.12.15.1. Deployment Manager template for the bootstrap machine

You can use the following Deployment Manager template to deploy the bootstrap machine that you need for your OpenShift Container Platform cluster:

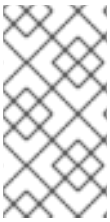
Example 8.97. 04_bootstrap.py Deployment Manager template

```
def GenerateConfig(context):

    resources = [{
        'name': context.properties['infra_id'] + '-bootstrap-public-ip',
        'type': 'compute.v1.address',
        'properties': {
            'region': context.properties['region']
        }
    }, {
        'name': context.properties['infra_id'] + '-bootstrap',
        'type': 'compute.v1.instance',
        'properties': {
            'disks': [{
                'autoDelete': True,
                'boot': True,
                'initializeParams': {
                    'diskSizeGb': context.properties['root_volume_size'],
                    'sourceImage': context.properties['image']
                }
            }],
            'machineType': 'zones/' + context.properties['zone'] + '/machineTypes/' +
context.properties['machine_type'],
            'metadata': {
                'items': [{
                    'key': 'user-data',
                    'value': '{"ignition":{"config":{"replace":{"source":"' + context.properties['bootstrap_ign']
+ '"}},"version":"3.2.0"}}',
                }]
            },
            'networkInterfaces': [{
                'subnetwork': context.properties['control_subnet'],
                'accessConfigs': [{
                    'natIP': '$(ref.' + context.properties['infra_id'] + '-bootstrap-public-ip.address)'
                }]
            }],
            'tags': {
                'items': [
                    context.properties['infra_id'] + '-master',
                    context.properties['infra_id'] + '-bootstrap'
                ]
            },
            'zone': context.properties['zone']
```

```
        }
    }, {
        'name': context.properties['infra_id'] + '-bootstrap-ig',
        'type': 'compute.v1.instanceGroup',
        'properties': {
            'namedPorts': [
                {
                    'name': 'ignition',
                    'port': 22623
                }, {
                    'name': 'https',
                    'port': 6443
                }
            ],
            'network': context.properties['cluster_network'],
            'zone': context.properties['zone']
        }
    }]

    return {'resources': resources}
```

8.12.16. Creating the control plane machines in GCP

You must create the control plane machines in Google Cloud Platform (GCP) for your cluster to use. One way to create these machines is to modify the provided Deployment Manager template.



NOTE

If you do not use the provided Deployment Manager template to create your control plane machines, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

Prerequisites

- Configure a GCP account.
- Generate the Ignition config files for your cluster.
- Create and configure a VPC and associated subnets in GCP.
- Create and configure networking and load balancers in GCP.
- Create control plane and compute roles.
- Create the bootstrap machine.

Procedure

1. Copy the template from the **Deployment Manager template for control plane machines** section of this topic and save it as **05_control_plane.py** on your computer. This template describes the control plane machines that your cluster requires.
2. Export the following variable required by the resource definition:

```
$ export MASTER_IGNITION=`cat <installation_directory>/master.ign`
```

3. Create a **05_control_plane.yaml** resource definition file:

```
$ cat <<EOF >05_control_plane.yaml
imports:
- path: 05_control_plane.py

resources:
- name: cluster-control-plane
  type: 05_control_plane.py
  properties:
    infra_id: '${INFRA_ID}' (1)
    zones: (2)
    - '${ZONE_0}'
    - '${ZONE_1}'
    - '${ZONE_2}'

    control_subnet: '${CONTROL_SUBNET}' (3)
    image: '${CLUSTER_IMAGE}' (4)
    machine_type: 'n1-standard-4' (5)
    root_volume_size: '128'
    service_account_email: '${MASTER_SERVICE_ACCOUNT}' (6)

    ignition: '${MASTER_IGNITION}' (7)
EOF
```

(1) **infra_id** is the **INFRA_ID** infrastructure name from the extraction step.

(2) **zones** are the zones to deploy the control plane instances into, for example **us-central1-a**, **us-central1-b**, and **us-central1-c**.

(3) **control_subnet** is the **selfLink** URL to the control subnet.

(4) **image** is the **selfLink** URL to the RHCOS image.

(5) **machine_type** is the machine type of the instance, for example **n1-standard-4**.

(6) **service_account_email** is the email address for the master service account that you created.

(7) **ignition** is the contents of the **master.ign** file.

4. Create the deployment by using the **gcloud** CLI:

```
$ gcloud deployment-manager deployments create ${INFRA_ID}-control-plane --config
05_control_plane.yaml
```

5. The templates do not manage load balancer membership due to limitations of Deployment Manager, so you must add the control plane machines manually.

   - Run the following commands to add the control plane machines to the appropriate instance groups:

     ■

```
$ gcloud compute instance-groups unmanaged add-instances ${INFRA_ID}-master-
${ZONE_0}-ig --zone=${ZONE_0} --instances=${INFRA_ID}-master-0
```

```
$ gcloud compute instance-groups unmanaged add-instances ${INFRA_ID}-master-
${ZONE_1}-ig --zone=${ZONE_1} --instances=${INFRA_ID}-master-1
```

```
$ gcloud compute instance-groups unmanaged add-instances ${INFRA_ID}-master-
${ZONE_2}-ig --zone=${ZONE_2} --instances=${INFRA_ID}-master-2
```

- For an external cluster, you must also run the following commands to add the control plane machines to the target pools:

```
$ gcloud compute target-pools add-instances ${INFRA_ID}-api-target-pool --instances-
zone="${ZONE_0}" --instances=${INFRA_ID}-master-0
```

```
$ gcloud compute target-pools add-instances ${INFRA_ID}-api-target-pool --instances-
zone="${ZONE_1}" --instances=${INFRA_ID}-master-1
```

```
$ gcloud compute target-pools add-instances ${INFRA_ID}-api-target-pool --instances-
zone="${ZONE_2}" --instances=${INFRA_ID}-master-2
```

8.12.16.1. Deployment Manager template for control plane machines

You can use the following Deployment Manager template to deploy the control plane machines that you need for your OpenShift Container Platform cluster:

Example 8.98. 05_control_plane.py Deployment Manager template

```
def GenerateConfig(context):

    resources = [{
        'name': context.properties['infra_id'] + '-master-0',
        'type': 'compute.v1.instance',
        'properties': {
            'disks': [{
                'autoDelete': True,
                'boot': True,
                'initializeParams': {
                    'diskSizeGb': context.properties['root_volume_size'],
                    'diskType': 'zones/' + context.properties['zones'][0] + '/diskTypes/pd-ssd',
                    'sourceImage': context.properties['image']
                }
            }],
            'machineType': 'zones/' + context.properties['zones'][0] + '/machineTypes/' +
context.properties['machine_type'],
            'metadata': {
                'items': [{
                    'key': 'user-data',
                    'value': context.properties['ignition']
                }]
            },
            'networkInterfaces': [{
                'subnetwork': context.properties['control_subnet']
```

```
            }],
            'serviceAccounts': [{
                'email': context.properties['service_account_email'],
                'scopes': ['https://www.googleapis.com/auth/cloud-platform']
            }],
            'tags': {
                'items': [
                    context.properties['infra_id'] + '-master',
                ]
            },
            'zone': context.properties['zones'][0]
        }
    }, {
        'name': context.properties['infra_id'] + '-master-1',
        'type': 'compute.v1.instance',
        'properties': {
            'disks': [{
                'autoDelete': True,
                'boot': True,
                'initializeParams': {
                    'diskSizeGb': context.properties['root_volume_size'],
                    'diskType': 'zones/' + context.properties['zones'][1] + '/diskTypes/pd-ssd',
                    'sourceImage': context.properties['image']
                }
            }],
            'machineType': 'zones/' + context.properties['zones'][1] + '/machineTypes/' +
context.properties['machine_type'],
            'metadata': {
                'items': [{
                    'key': 'user-data',
                    'value': context.properties['ignition']
                }]
            },
            'networkInterfaces': [{
                'subnetwork': context.properties['control_subnet']
            }],
            'serviceAccounts': [{
                'email': context.properties['service_account_email'],
                'scopes': ['https://www.googleapis.com/auth/cloud-platform']
            }],
            'tags': {
                'items': [
                    context.properties['infra_id'] + '-master',
                ]
            },
            'zone': context.properties['zones'][1]
        }
    }, {
        'name': context.properties['infra_id'] + '-master-2',
        'type': 'compute.v1.instance',
        'properties': {
            'disks': [{
                'autoDelete': True,
                'boot': True,
                'initializeParams': {
                    'diskSizeGb': context.properties['root_volume_size'],
```

```
                'diskType': 'zones/' + context.properties['zones'][2] + '/diskTypes/pd-ssd',
                'sourceImage': context.properties['image']
            }
        }],
        'machineType': 'zones/' + context.properties['zones'][2] + '/machineTypes/' +
context.properties['machine_type'],
        'metadata': {
            'items': [{
                'key': 'user-data',
                'value': context.properties['ignition']
            }]
        },
        'networkInterfaces': [{
            'subnetwork': context.properties['control_subnet']
        }],
        'serviceAccounts': [{
            'email': context.properties['service_account_email'],
            'scopes': ['https://www.googleapis.com/auth/cloud-platform']
        }],
        'tags': {
            'items': [
                context.properties['infra_id'] + '-master',
            ]
        },
        'zone': context.properties['zones'][2]
    }
}]

return {'resources': resources}
```

8.12.17. Wait for bootstrap completion and remove bootstrap resources in GCP

After you create all of the required infrastructure in Google Cloud Platform (GCP), wait for the bootstrap process to complete on the machines that you provisioned by using the Ignition config files that you generated with the installation program.

Prerequisites

- Configure a GCP account.
- Generate the Ignition config files for your cluster.
- Create and configure a VPC and associated subnets in GCP.
- Create and configure networking and load balancers in GCP.
- Create control plane and compute roles.
- Create the bootstrap machine.
- Create the control plane machines.

Procedure

1. Change to the directory that contains the installation program and run the following command:

```
$ ./openshift-install wait-for bootstrap-complete --dir <installation_directory> \ 1
    --log-level info 2
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

If the command exits without a **FATAL** warning, your production control plane has initialized.

2. Delete the bootstrap resources:

```
$ gcloud compute backend-services remove-backend ${INFRA_ID}-api-internal-backend-
service --region=${REGION} --instance-group=${INFRA_ID}-bootstrap-ig --instance-group-
zone=${ZONE_0}
```

```
$ gsutil rm gs://${INFRA_ID}-bootstrap-ignition/bootstrap.ign
```

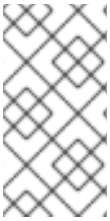
```
$ gsutil rb gs://${INFRA_ID}-bootstrap-ignition
```

```
$ gcloud deployment-manager deployments delete ${INFRA_ID}-bootstrap
```

8.12.18. Creating additional worker machines in GCP

You can create worker machines in Google Cloud Platform (GCP) for your cluster to use by launching individual instances discretely or by automated processes outside the cluster, such as auto scaling groups. You can also take advantage of the built-in cluster scaling mechanisms and the machine API in OpenShift Container Platform.

In this example, you manually launch one instance by using the Deployment Manager template. Additional instances can be launched by including additional resources of type **06_worker.py** in the file.



NOTE

If you do not use the provided Deployment Manager template to create your worker machines, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

Prerequisites

- Configure a GCP account.
- Generate the Ignition config files for your cluster.
- Create and configure a VPC and associated subnets in GCP.
- Create and configure networking and load balancers in GCP.
- Create control plane and compute roles.

- Create the bootstrap machine.
- Create the control plane machines.

Procedure

1. Copy the template from the **Deployment Manager template for worker machines** section of this topic and save it as **06_worker.py** on your computer. This template describes the worker machines that your cluster requires.
2. Export the variables that the resource definition uses.
   a. Export the subnet that hosts the compute machines:

      ```
      $ export COMPUTE_SUBNET=(`gcloud compute networks subnets describe
      ${INFRA_ID}-worker-subnet --region=${REGION} --format json | jq -r .selfLink`)
      ```

   b. Export the email address for your service account:

      ```
      $ export WORKER_SERVICE_ACCOUNT=(`gcloud iam service-accounts list --filter
      "email~^${INFRA_ID}-w@${PROJECT_NAME}." --format json | jq -r '.[0].email'`)
      ```

   c. Export the location of the compute machine Ignition config file:

      ```
      $ export WORKER_IGNITION=`cat <installation_directory>/worker.ign`
      ```

3. Create a **06_worker.yaml** resource definition file:

```
$ cat <<EOF >06_worker.yaml
imports:
- path: 06_worker.py

resources:
- name: 'worker-0' (1)
  type: 06_worker.py
  properties:
    infra_id: '${INFRA_ID}' (2)
    zone: '${ZONE_0}' (3)
    compute_subnet: '${COMPUTE_SUBNET}' (4)
    image: '${CLUSTER_IMAGE}' (5)
    machine_type: 'n1-standard-4' (6)
    root_volume_size: '128'
    service_account_email: '${WORKER_SERVICE_ACCOUNT}' (7)
    ignition: '${WORKER_IGNITION}' (8)
- name: 'worker-1'
  type: 06_worker.py
  properties:
    infra_id: '${INFRA_ID}' (9)
    zone: '${ZONE_1}' (10)
    compute_subnet: '${COMPUTE_SUBNET}' (11)
    image: '${CLUSTER_IMAGE}' (12)
    machine_type: 'n1-standard-4' (13)
    root_volume_size: '128'
```

```
    service_account_email: '${WORKER_SERVICE_ACCOUNT}' 14
    ignition: '${WORKER_IGNITION}' 15
EOF
```

1 **name** is the name of the worker machine, for example **worker-0**.

2 9 **infra_id** is the **INFRA_ID** infrastructure name from the extraction step.

3 10 **zone** is the zone to deploy the worker machine into, for example **us-central1-a**.

4 11 **compute_subnet** is the **selfLink** URL to the compute subnet.

5 12 **image** is the **selfLink** URL to the RHCOS image. [1]

6 13 **machine_type** is the machine type of the instance, for example **n1-standard-4**.

7 14 **service_account_email** is the email address for the worker service account that you created.

8 15 **ignition** is the contents of the **worker.ign** file.

4. Optional: If you want to launch additional instances, include additional resources of type **06_worker.py** in your **06_worker.yaml** resource definition file.

5. Create the deployment by using the **gcloud** CLI:

```
$ gcloud deployment-manager deployments create ${INFRA_ID}-worker --config
06_worker.yaml
```

1. To use a GCP Marketplace image, specify the offer to use:

   - OpenShift Container Platform: **https://www.googleapis.com/compute/v1/projects/redhat-marketplace-public/global/images/redhat-coreos-ocp-48-x86-64-202210040145**
   - OpenShift Platform Plus: **https://www.googleapis.com/compute/v1/projects/redhat-marketplace-public/global/images/redhat-coreos-opp-48-x86-64-202206140145**
   - OpenShift Kubernetes Engine: **https://www.googleapis.com/compute/v1/projects/redhat-marketplace-public/global/images/redhat-coreos-oke-48-x86-64-202206140145**

8.12.18.1. Deployment Manager template for worker machines

You can use the following Deployment Manager template to deploy the worker machines that you need for your OpenShift Container Platform cluster:

Example 8.99. 06_worker.py Deployment Manager template

```
def GenerateConfig(context):

    resources = [{
        'name': context.properties['infra_id'] + '-' + context.env['name'],
        'type': 'compute.v1.instance',
```

```
        'properties': {
            'disks': [{
                'autoDelete': True,
                'boot': True,
                'initializeParams': {
                    'diskSizeGb': context.properties['root_volume_size'],
                    'sourceImage': context.properties['image']
                }
            }],
            'machineType': 'zones/' + context.properties['zone'] + '/machineTypes/' +
context.properties['machine_type'],
            'metadata': {
                'items': [{
                    'key': 'user-data',
                    'value': context.properties['ignition']
                }]
            },
            'networkInterfaces': [{
                'subnetwork': context.properties['compute_subnet']
            }],
            'serviceAccounts': [{
                'email': context.properties['service_account_email'],
                'scopes': ['https://www.googleapis.com/auth/cloud-platform']
            }],
            'tags': {
                'items': [
                    context.properties['infra_id'] + '-worker',
                ]
            },
            'zone': context.properties['zone']
        }
    }]

    return {'resources': resources}
```

8.12.19. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

Example output

```
system:admin
```

8.12.20. Disabling the default OperatorHub sources

Operator catalogs that source content provided by Red Hat and community projects are configured for OperatorHub by default during an OpenShift Container Platform installation. In a restricted network environment, you must disable the default catalogs as a cluster administrator.

Procedure

- Disable the sources for the default catalogs by adding **disableAllDefaultSources: true** to the **OperatorHub** object:

```
$ oc patch OperatorHub cluster --type json \
    -p '[{"op": "add", "path": "/spec/disableAllDefaultSources", "value": true}]'
```

TIP

Alternatively, you can use the web console to manage catalog sources. From the **Administration → Cluster Settings → Configuration → OperatorHub** page, click the **Sources** tab, where you can create, update, delete, disable, and enable individual sources.

8.12.21. Approving the certificate signing requests for your machines

When you add machines to a cluster, two pending certificate signing requests (CSRs) are generated for each machine that you added. You must confirm that these CSRs are approved or, if necessary, approve them yourself. The client requests must be approved first, followed by the server requests.

Prerequisites

- You added machines to your cluster.

Procedure

1. Confirm that the cluster recognizes the machines:

```
$ oc get nodes
```

Example output

```
NAME      STATUS    ROLES   AGE  VERSION
master-0  Ready     master  63m  v1.24.0
```

```
master-1  Ready    master  63m  v1.24.0
master-2  Ready    master  64m  v1.24.0
```

The output lists all of the machines that you created.

NOTE

The preceding output might not include the compute nodes, also known as worker nodes, until some CSRs are approved.

2. Review the pending CSRs and ensure that you see the client requests with the **Pending** or **Approved** status for each machine that you added to the cluster:

```
$ oc get csr
```

Example output

```
NAME        AGE    REQUESTOR                                                   CONDITION
csr-8b2br   15m    system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper   Pending
csr-8vnps   15m    system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper   Pending
...
```

In this example, two machines are joining the cluster. You might see more approved CSRs in the list.

3. If the CSRs were not approved, after all of the pending CSRs for the machines you added are in **Pending** status, approve the CSRs for your cluster machines:

NOTE

Because the CSRs rotate automatically, approve your CSRs within an hour of adding the machines to the cluster. If you do not approve them within an hour, the certificates will rotate, and more than two certificates will be present for each node. You must approve all of these certificates. After the client CSR is approved, the Kubelet creates a secondary CSR for the serving certificate, which requires manual approval. Then, subsequent serving certificate renewal requests are automatically approved by the **machine-approver** if the Kubelet requests a new certificate with identical parameters.

NOTE

For clusters running on platforms that are not machine API enabled, such as bare metal and other user-provisioned infrastructure, you must implement a method of automatically approving the kubelet serving certificate requests (CSRs). If a request is not approved, then the **oc exec**, **oc rsh**, and **oc logs** commands cannot succeed, because a serving certificate is required when the API server connects to the kubelet. Any operation that contacts the Kubelet endpoint requires this certificate approval to be in place. The method must watch for new CSRs, confirm that the CSR was submitted by the **node-bootstrapper** service account in the **system:node** or **system:admin** groups, and confirm the identity of the node.

- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

1 **<csr_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{{"\n"}}
{{end}}{{end}}' | xargs --no-run-if-empty oc adm certificate approve
```

NOTE

Some Operators might not become available until some CSRs are approved.

4. Now that your client requests are approved, you must review the server requests for each machine that you added to the cluster:

```
$ oc get csr
```

Example output

```
NAME        AGE     REQUESTOR                                                   CONDITION
csr-bfd72   5m26s   system:node:ip-10-0-50-126.us-east-2.compute.internal
Pending
csr-c57lv   5m26s   system:node:ip-10-0-95-157.us-east-2.compute.internal
Pending
...
```

5. If the remaining CSRs are not approved, and are in the **Pending** status, approve the CSRs for your cluster machines:

- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

1 **<csr_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

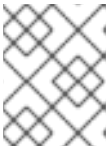
```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{{"\n"}}
{{end}}{{end}}' | xargs oc adm certificate approve
```

6. After all client and server CSRs have been approved, the machines have the **Ready** status. Verify this by running the following command:

```
$ oc get nodes
```

Example output

```
NAME     STATUS   ROLES   AGE  VERSION
master-0 Ready    master  73m  v1.24.0
master-1 Ready    master  73m  v1.24.0
master-2 Ready    master  74m  v1.24.0
worker-0 Ready    worker  11m  v1.24.0
worker-1 Ready    worker  11m  v1.24.0
```



NOTE

It can take a few minutes after approval of the server CSRs for the machines to transition to the **Ready** status.

Additional information

- For more information on CSRs, see Certificate Signing Requests .

8.12.22. Optional: Adding the ingress DNS records

If you removed the DNS zone configuration when creating Kubernetes manifests and generating Ignition configs, you must manually create DNS records that point at the ingress load balancer. You can create either a wildcard ***.apps.{baseDomain}.** or specific records. You can use A, CNAME, and other records per your requirements.

Prerequisites

- Configure a GCP account.
- Remove the DNS Zone configuration when creating Kubernetes manifests and generating Ignition configs.
- Create and configure a VPC and associated subnets in GCP.
- Create and configure networking and load balancers in GCP.
- Create control plane and compute roles.
- Create the bootstrap machine.
- Create the control plane machines.
- Create the worker machines.

Procedure

1. Wait for the Ingress router to create a load balancer and populate the **EXTERNAL-IP** field:

```
$ oc -n openshift-ingress get service router-default
```

Example output

```
NAME             TYPE           CLUSTER-IP      EXTERNAL-IP     PORT(S)                      AGE
router-default   LoadBalancer   172.30.18.154   35.233.157.184
80:32288/TCP,443:31215/TCP   98
```

2. Add the A record to your zones:

   - To use A records:

     i. Export the variable for the router IP address:

     ```
     $ export ROUTER_IP=`oc -n openshift-ingress get service router-default --no-
     headers | awk '{print $4}'`
     ```

     ii. Add the A record to the private zones:

     ```
     $ if [ -f transaction.yaml ]; then rm transaction.yaml; fi
     $ gcloud dns record-sets transaction start --zone ${INFRA_ID}-private-zone
     $ gcloud dns record-sets transaction add ${ROUTER_IP} --name
     \*.apps.${CLUSTER_NAME}.${BASE_DOMAIN}. --ttl 300 --type A --zone
     ${INFRA_ID}-private-zone
     $ gcloud dns record-sets transaction execute --zone ${INFRA_ID}-private-zone
     ```

     iii. For an external cluster, also add the A record to the public zones:

     ```
     $ if [ -f transaction.yaml ]; then rm transaction.yaml; fi
     $ gcloud dns record-sets transaction start --zone ${BASE_DOMAIN_ZONE_NAME}
     $ gcloud dns record-sets transaction add ${ROUTER_IP} --name
     \*.apps.${CLUSTER_NAME}.${BASE_DOMAIN}. --ttl 300 --type A --zone
     ${BASE_DOMAIN_ZONE_NAME}
     $ gcloud dns record-sets transaction execute --zone
     ${BASE_DOMAIN_ZONE_NAME}
     ```

   - To add explicit domains instead of using a wildcard, create entries for each of the cluster's current routes:

     ```
     $ oc get --all-namespaces -o jsonpath='{range .items[*]}{range .status.ingress[*]}{.host}
     {"\n"}{end}{end}' routes
     ```

     Example output

     ```
     oauth-openshift.apps.your.cluster.domain.example.com
     console-openshift-console.apps.your.cluster.domain.example.com
     downloads-openshift-console.apps.your.cluster.domain.example.com
     alertmanager-main-openshift-monitoring.apps.your.cluster.domain.example.com
     prometheus-k8s-openshift-monitoring.apps.your.cluster.domain.example.com
     ```

8.12.23. Completing a GCP installation on user-provisioned infrastructure

After you start the OpenShift Container Platform installation on Google Cloud Platform (GCP) user-provisioned infrastructure, you can monitor the cluster events until the cluster is ready.

Prerequisites

- Deploy the bootstrap machine for an OpenShift Container Platform cluster on user-provisioned GCP infrastructure.
- Install the **oc** CLI and log in.

Procedure

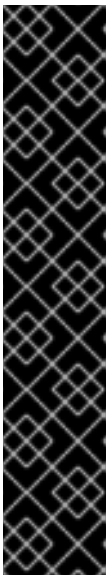
1. Complete the cluster installation:

```
$ ./openshift-install --dir <installation_directory> wait-for install-complete 1
```

Example output

```
INFO Waiting up to 30m0s for the cluster to initialize...
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.



IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

2. Observe the running state of your cluster.

   a. Run the following command to view the current cluster version and status:

```
$ oc get clusterversion
```

Example output

```
NAME     VERSION   AVAILABLE   PROGRESSING   SINCE   STATUS
version          False       True          24m     Working towards 4.5.4: 99% complete
```

   b. Run the following command to view the Operators managed on the control plane by the Cluster Version Operator (CVO):

```
$ oc get clusteroperators
```

Example output

```
NAME                                 VERSION   AVAILABLE   PROGRESSING   DEGRADED
SINCE
authentication                       4.5.4     True        False         False     7m56s
cloud-credential                     4.5.4     True        False         False     31m
```

```
cluster-autoscaler                         4.5.4     True        False         False      16m
console                                    4.5.4     True        False         False      10m
csi-snapshot-controller                    4.5.4     True        False         False      16m
dns                                        4.5.4     True        False         False      22m
etcd                                       4.5.4     False       False         False      25s
image-registry                             4.5.4     True        False         False      16m
ingress                                    4.5.4     True        False         False      16m
insights                                   4.5.4     True        False         False      17m
kube-apiserver                             4.5.4     True        False         False      19m
kube-controller-manager                    4.5.4     True        False         False      20m
kube-scheduler                             4.5.4     True        False         False      20m
kube-storage-version-migrator              4.5.4     True        False         False      16m
machine-api                                4.5.4     True        False         False      22m
machine-config                             4.5.4     True        False         False      22m
marketplace                                4.5.4     True        False         False      16m
monitoring                                 4.5.4     True        False         False      10m
network                                    4.5.4     True        False         False      23m
node-tuning                                4.5.4     True        False         False      23m
openshift-apiserver                        4.5.4     True        False         False      17m
openshift-controller-manager               4.5.4     True        False         False      15m
openshift-samples                          4.5.4     True        False         False      16m
operator-lifecycle-manager                 4.5.4     True        False         False      22m
operator-lifecycle-manager-catalog         4.5.4     True        False         False      22m
operator-lifecycle-manager-packageserver   4.5.4     True        False         False      18m
service-ca                                 4.5.4     True        False         False      23m
service-catalog-apiserver                  4.5.4     True        False         False      23m
service-catalog-controller-manager         4.5.4     True        False         False      23m
storage                                    4.5.4     True        False         False      17m
```

c. Run the following command to view your cluster pods:

```
$ oc get pods --all-namespaces
```

Example output

```
NAMESPACE                                          NAME
READY   STATUS      RESTARTS   AGE
kube-system                                        etcd-member-ip-10-0-3-111.us-east-
2.compute.internal              1/1     Running     0          35m
kube-system                                        etcd-member-ip-10-0-3-239.us-east-
2.compute.internal              1/1     Running     0          37m
kube-system                                        etcd-member-ip-10-0-3-24.us-east-
2.compute.internal              1/1     Running     0          35m
openshift-apiserver-operator                       openshift-apiserver-operator-6d6674f4f4-
h7t2t                           1/1     Running     1          37m
openshift-apiserver                                apiserver-fm48r
1/1     Running     0          30m
openshift-apiserver                                apiserver-fxkvv
1/1     Running     0          29m
openshift-apiserver                                apiserver-q85nm
1/1     Running     0          29m
...
openshift-service-ca-operator                      openshift-service-ca-operator-66ff6dc6cd-
9r257                           1/1     Running     0          37m
openshift-service-ca                               apiservice-cabundle-injector-695b6bcbc-cl5hm
```

```
1/1     Running   0          35m
openshift-service-ca                               configmap-cabundle-injector-8498544d7-
25qn6                  1/1     Running   0          35m
openshift-service-ca                               service-serving-cert-signer-6445fc9c6-wqdqn
1/1     Running   0          35m
openshift-service-catalog-apiserver-operator       openshift-service-catalog-apiserver-
operator-549f44668b-b5q2w      1/1     Running   0          32m
openshift-service-catalog-controller-manager-operator   openshift-service-catalog-
controller-manager-operator-b78cr2lnm   1/1     Running   0          31m
```

When the current cluster version is **AVAILABLE**, the installation is complete.

8.12.24. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.11, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to OpenShift Cluster Manager Hybrid Cloud Console.

After you confirm that your OpenShift Cluster Manager Hybrid Cloud Console inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, use subscription watch to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

Additional resources

- See About remote health monitoring for more information about the Telemetry service

8.12.25. Next steps

- Customize your cluster.
- Configure image streams for the Cluster Samples Operator and the **must-gather** tool.
- Learn how to use Operator Lifecycle Manager (OLM) on restricted networks .
- If the mirror registry that you used to install your cluster has a trusted CA, add it to the cluster by configuring additional trust stores.
- If necessary, you can opt out of remote health reporting .
- If necessary, see Registering your disconnected cluster

8.13. UNINSTALLING A CLUSTER ON GCP

You can remove a cluster that you deployed to Google Cloud Platform (GCP).

8.13.1. Removing a cluster that uses installer-provisioned infrastructure

You can remove a cluster that uses installer-provisioned infrastructure from your cloud.

NOTE

After uninstallation, check your cloud provider for any resources not removed properly, especially with User Provisioned Infrastructure (UPI) clusters. There might be resources that the installer did not create or that the installer is unable to access. For example, some Google Cloud resources require IAM permissions in shared VPC host projects, or there might be unused health checks that must be deleted .

Prerequisites

- You have a copy of the installation program that you used to deploy the cluster.
- You have the files that the installation program generated when you created your cluster.

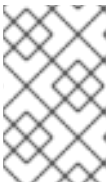
Procedure

1. On the computer that you used to install the cluster, go to the directory that contains the installation program, and run the following command:

```
$ ./openshift-install destroy cluster \
--dir <installation_directory> --log-level info 1 2
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2 To view different details, specify **warn**, **debug**, or **error** instead of **info**.



NOTE

You must specify the directory that contains the cluster definition files for your cluster. The installation program requires the **metadata.json** file in this directory to delete the cluster.

2. Optional: Delete the **<installation_directory>** directory and the OpenShift Container Platform installation program.

8.13.2. Deleting GCP resources with the Cloud Credential Operator utility

To clean up resources after uninstalling an OpenShift Container Platform cluster with the Cloud Credential Operator (CCO) in manual mode with GCP Workload Identity, you can use the CCO utility (**ccoctl**) to remove the GCP resources that **ccoctl** created during installation.

Prerequisites

- Extract and prepare the **ccoctl** binary.
- Install an OpenShift Container Platform cluster with the CCO in manual mode with GCP Workload Identity.

Procedure

1. Obtain the OpenShift Container Platform release image by running the following command:

```
$ RELEASE_IMAGE=$(./openshift-install version | awk '/release image/ {print $3}')
```

2. Extract the list of **CredentialsRequest** custom resources (CRs) from the OpenShift Container Platform release image by running the following command:

```
$ oc adm release extract --credentials-requests \
  --cloud=gcp \
  --to=<path_to_directory_with_list_of_credentials_requests>/credrequests \ 1
  $RELEASE_IMAGE
```

1 **credrequests** is the directory where the list of **CredentialsRequest** objects is stored. This command creates the directory if it does not exist.

3. Delete the GCP resources that **ccoctl** created:

```
$ ccoctl gcp delete \
  --name=<name> \ 1
  --project=<gcp_project_id> \ 2
  --credentials-requests-dir=
<path_to_directory_with_list_of_credentials_requests>/credrequests
```

1 **<name>** matches the name that was originally used to create and tag the cloud resources.

2 **<gcp_project_id>** is the GCP project ID in which to delete cloud resources.

Verification

- To verify that the resources are deleted, query GCP. For more information, refer to GCP documentation.

CHAPTER 9. INSTALLING ON IBM CLOUD VPC

9.1. PREPARING TO INSTALL ON IBM CLOUD VPC

The installation workflows documented in this section are for IBM Cloud VPC infrastructure environments. IBM Cloud Classic is not supported at this time. For more information on the difference between Classic and VPC infrastructures, see IBM's documentation.

9.1.1. Prerequisites

- You reviewed details about the OpenShift Container Platform installation and update processes.
- You read the documentation on selecting a cluster installation method and preparing it for users.

IMPORTANT

IBM Cloud using installer-provisioned infrastructure is a Technology Preview feature only. Technology Preview features are not supported with Red Hat production service level agreements (SLAs) and might not be functionally complete. Red Hat does not recommend using them in production. These features provide early access to upcoming product features, enabling customers to test functionality and provide feedback during the development process.

For more information about the support scope of Red Hat Technology Preview features, see Technology Preview Features Support Scope .

9.1.2. Requirements for installing OpenShift Container Platform on IBM Cloud VPC

Before installing OpenShift Container Platform on IBM Cloud VPC, you must create a service account and configure an IBM Cloud account. See Configuring an IBM Cloud account for details about creating an account, enabling API services, configuring DNS, IBM Cloud account limits, and supported IBM Cloud VPC regions.

You must manually manage your cloud credentials when installing a cluster to IBM Cloud VPC. Do this by configuring the Cloud Credential Operator (CCO) for manual mode before you install the cluster. For more information, see Configuring IAM for IBM Cloud VPC.

9.1.3. Choosing a method to install OpenShift Container Platform on IBM Cloud VPC

You can install OpenShift Container Platform on IBM Cloud VPC using installer-provisioned infrastructure. This process involves using an installation program to provision the underlying infrastructure for your cluster. Installing OpenShift Container Platform on IBM Cloud VPC using user-provisioned infrastructure is not supported at this time.

See Installation process for more information about installer-provisioned installation processes.

9.1.3.1. Installing a cluster on installer-provisioned infrastructure

You can install a cluster on IBM Cloud VPC infrastructure that is provisioned by the OpenShift Container Platform installation program by using one of the following methods:

- **Installing a customized cluster on IBM Cloud VPC**: You can install a customized cluster on IBM

Cloud VPC infrastructure that the installation program provisions. The installation program allows for some customization to be applied at the installation stage. Many other customization options are available post-installation.

- **Installing a cluster on IBM Cloud VPC with network customizations**You can customize your OpenShift Container Platform network configuration during installation, so that your cluster can coexist with your existing IP address allocations and adhere to your network requirements.

9.1.4. Next steps

- Configuring an IBM Cloud account

9.2. CONFIGURING AN IBM CLOUD ACCOUNT

Before you can install OpenShift Container Platform, you must configure an IBM Cloud account.

IMPORTANT

IBM Cloud VPC using installer-provisioned infrastructure is a Technology Preview feature only. Technology Preview features are not supported with Red Hat production service level agreements (SLAs) and might not be functionally complete. Red Hat does not recommend using them in production. These features provide early access to upcoming product features, enabling customers to test functionality and provide feedback during the development process.

For more information about the support scope of Red Hat Technology Preview features, see Technology Preview Features Support Scope .

9.2.1. Prerequisites

- You have an IBM Cloud account with a subscription. You cannot install OpenShift Container Platform on a free or trial IBM Cloud account.

9.2.2. Quotas and limits on IBM Cloud VPC

The OpenShift Container Platform cluster uses a number of IBM Cloud VPC components, and the default quotas and limits affect your ability to install OpenShift Container Platform clusters. If you use certain cluster configurations, deploy your cluster in certain regions, or run multiple clusters from your account, you might need to request additional resources for your IBM Cloud account.

For a comprehensive list of the default IBM Cloud VPC quotas and service limits, see IBM Cloud's documentation for Quotas and service limits .

Virtual Private Cloud (VPC)
Each OpenShift Container Platform cluster creates its own VPC. The default quota of VPCs per region is 10 and will allow 10 clusters. To have more than 10 clusters in a single region, you must increase this quota.

Application load balancer
By default, each cluster creates three application load balancers (ALBs):

- Internal load balancer for the master API server
- External load balancer for the master API server

- Load balancer for the router

You can create additional **LoadBalancer** service objects to create additional ALBs. The default quota of VPC ALBs are 50 per region. To have more than 50 ALBs, you must increase this quota.

VPC ALBs are supported. Classic ALBs are not supported for IBM Cloud VPC.

Floating IP address
By default, the installation program distributes control plane and compute machines across all availability zones within a region to provision the cluster in a highly available configuration. In each availability zone, a public gateway is created and requires a separate floating IP address.

The default quota for a floating IP address is 20 addresses per availability zone. The default cluster configuration yields three floating IP addresses:

- Two floating IP addresses in the **us-east-1** primary zone. The IP address associated with the bootstrap node is removed after installation.
- One floating IP address in the **us-east-2** secondary zone.
- One floating IP address in the **us-east-3** secondary zone.

IBM Cloud VPC can support up to 19 clusters per region in an account. If you plan to have more than 19 default clusters, you must increase this quota.

Virtual Server Instances (VSI)
By default, a cluster creates VSIs using **bx2-4x16** profiles, which includes the following resources by default:

- 4 vCPUs
- 16 GB RAM

The following nodes are created:

- One **bx2-4x16** bootstrap machine, which is removed after the installation is complete
- Three **bx2-4x16** control plane nodes
- Three **bx2-4x16** compute nodes

For more information, see IBM Cloud's documentation on supported profiles.

Table 9.1. VSI component quotas and limits

VSI component	Default IBM Cloud VPC quota	Default cluster configuration	Maximum number of clusters
vCPU	200 vCPUs per region	28 vCPUs, or 24 vCPUs after bootstrap removal	8 per region
RAM	1600 GB per region	112 GB, or 96 GB after bootstrap removal	16 per region

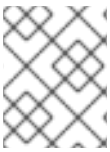
VSI component	Default IBM Cloud VPC quota	Default cluster configuration	Maximum number of clusters
Storage	18 TB per region	1050 GB, or 900 GB after bootstrap removal	19 per region

If you plan to exceed the resources stated in the table, you must increase your IBM Cloud account quota.

Block Storage Volumes
For each VPC machine, a block storage device is attached for its boot volume. The default cluster configuration creates seven VPC machines, resulting in seven block storage volumes. Additional Kubernetes persistent volume claims (PVCs) of the IBM Cloud VPC storage class create additional block storage volumes. The default quota of VPC block storage volumes are 300 per region. To have more than 300 volumes, you must increase this quota.

9.2.3. Configuring DNS resolution using Cloud Internet Services

IBM Cloud Internet Services (CIS) is used by the installation program to configure cluster DNS resolution and provide name lookup for the cluster to external resources. Only public DNS is supported with IBM Cloud VPC.



NOTE

IBM Cloud VPC does not support IPv6, so dual stack or IPv6 environments are not possible.

You must create a domain zone in CIS in the same account as your cluster. You must also ensure the zone is authoritative for the domain. You can do this using a root domain or subdomain.

Prerequisites

- You have installed the IBM Cloud CLI.

Procedure

1. If you do not already have an existing domain and registrar, you must acquire them. For more information, see IBM's documentation.
2. Create a CIS instance to use with your cluster.
   a. Install the CIS plugin:

```
$ ibmcloud plugin install cis
```

   b. Create the CIS instance:

```
$ ibmcloud cis instance-create <instance_name> standard 1
```

1 At a minimum, a **Standard** plan is required for CIS to manage the cluster subdomain and its DNS records.

3. Connect an existing domain to your CIS instance.

   a. Set the context instance for CIS:

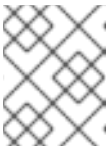
   ```
   $ ibmcloud cis instance-set <instance_name> 1
   ```

   1 The instance cloud resource name.

   b. Add the domain for CIS:

   ```
   $ ibmcloud cis domain-add <domain_name> 1
   ```

   1 The fully qualified domain name. You can use either the root domain or subdomain value as the domain name, depending on which you plan to configure.

   NOTE

   A root domain uses the form **openshiftcorp.com**. A subdomain uses the form **clusters.openshiftcorp.com**.

4. Open the CIS web console, navigate to the **Overview** page, and note your CIS name servers. These name servers will be used in the next step.

5. Configure the name servers for your domains or subdomains at the domain's registrar or DNS provider. For more information, see IBM Cloud's documentation.

9.2.4. IBM Cloud VPC IAM Policies and API Key

To install OpenShift Container Platform into your IBM Cloud account, the installation program requires an IAM API key, which provides authentication and authorization to access IBM Cloud service APIs. You can use an existing IAM API key that contains the required policies or create a new one.

For an IBM Cloud IAM overview, see the IBM Cloud documentation.

9.2.4.1. Required access policies

You must assign the required access policies to your IBM Cloud account.

Table 9.2. Required access policies

Service type	Service	Access policy scope	Platform access	Service access
Account management	IAM Identity Service	All resources or a subset of resources [1]	Editor, Operator, Viewer, Administrator	Service ID creator

Service type	Service	Access policy scope	Platform access	Service access
Account management [2]	Identity and Access Management	All resources	Editor, Operator, Viewer, Administrator	
Account management	Resource group only	All resource groups in the account	Administrator	
IAM services	Cloud Object Storage	All resources or a subset of resources [1]	Editor, Operator, Viewer, Administrator	Reader, Writer, Manager, Content Reader, Object Reader, Object Writer
IAM services	Internet Services	All resources or a subset of resources [1]	Editor, Operator, Viewer, Administrator	Reader, Writer, Manager
IAM services	VPC Infrastructure Services	All resources or a subset of resources [1]	Editor, Operator, Viewer, Administrator	Reader, Writer, Manager

1. The policy access scope should be set based on how granular you want to assign access. The scope can be set to **All resources** or **Resources based on selected attributes**
2. Optional: This access policy is only required if you want the installation program to create a resource group. For more information on resource groups, see IBM Cloud's documentation.

9.2.4.2. Access policy assignment

In IBM Cloud VPC IAM, access policies can be attached to different subjects:

- Access group (Recommended)
- Service ID
- User

The recommended method is to define IAM access policies in an access group. This helps organize all the access required for OpenShift Container Platform and enables you to onboard users and service IDs to this group. You can also assign access to users and service IDs directly, if desired.

9.2.4.3. Creating an API key

You must create a user API key or a service ID API key for your IBM Cloud account.

Prerequisites

- You have assigned the required access policies to your IBM Cloud account.
- You have attached you IAM access policies to an access group, or other appropriate resource.

Procedure

- Create an API key, depending on how you defined your IAM access policies.
  For example, if you assigned your access policies to a user, you must create a user API key. If you assigned your access policies to a service ID, you must create a service ID API key. If your access policies are assigned to an access group, you can use either API key type. For more information on IBM Cloud VPC API keys, see Understanding API keys.

9.2.5. Supported IBM Cloud VPC regions

You can deploy an OpenShift Container Platform cluster to the following regions:

- **au-syd** (Sydney, Australia)
- **br-sao** (Sao Paulo, Brazil)
- **ca-tor** (Toronto, Canada)
- **eu-de** (Frankfurt, Germany)
- **eu-gb** (London, United Kingdom)
- **jp-osa** (Osaka, Japan)
- **jp-tok** (Tokyo, Japan)
- **us-east** (Washington DC, United States)
- **us-south** (Dallas, United States)

9.2.6. Next steps

- Configuring IAM for IBM Cloud VPC

9.3. CONFIGURING IAM FOR IBM CLOUD VPC

In environments where the cloud identity and access management (IAM) APIs are not reachable, you must put the Cloud Credential Operator (CCO) into manual mode before you install the cluster.

IMPORTANT

IBM Cloud VPC using installer-provisioned infrastructure is a Technology Preview feature only. Technology Preview features are not supported with Red Hat production service level agreements (SLAs) and might not be functionally complete. Red Hat does not recommend using them in production. These features provide early access to upcoming product features, enabling customers to test functionality and provide feedback during the development process.

For more information about the support scope of Red Hat Technology Preview features, see Technology Preview Features Support Scope .

9.3.1. Alternatives to storing administrator-level secrets in the kube-system project

The Cloud Credential Operator (CCO) manages cloud provider credentials as Kubernetes custom resource definitions (CRDs). You can configure the CCO to suit the security requirements of your organization by setting different values for the **credentialsMode** parameter in the **install-config.yaml** file.

Storing an administrator-level credential secret in the cluster **kube-system** project is not supported for IBM Cloud; therefore, you must set the **credentialsMode** parameter for the CCO to **Manual** when installing OpenShift Container Platform and manage your cloud credentials manually.

Using manual mode allows each cluster component to have only the permissions it requires, without storing an administrator-level credential in the cluster. You can also use this mode if your environment does not have connectivity to the cloud provider public IAM endpoint. However, you must manually reconcile permissions with new release images for every upgrade. You must also manually supply credentials for every component that requests them.

Additional resources

- About the Cloud Credential Operator

9.3.2. Configuring the Cloud Credential Operator utility

To create and manage cloud credentials from outside of the cluster when the Cloud Credential Operator (CCO) is operating in manual mode, extract and prepare the CCO utility (**ccoctl**) binary.

NOTE

The **ccoctl** utility is a Linux binary that must run in a Linux environment.

Prerequisites

- You have access to an OpenShift Container Platform account with cluster administrator access.
- You have installed the OpenShift CLI (**oc**).

Procedure

1. Obtain the OpenShift Container Platform release image by running the following command:

```
$ RELEASE_IMAGE=$(./openshift-install version | awk '/release image/ {print $3}')
```

2. Obtain the CCO container image from the OpenShift Container Platform release image by running the following command:

```
$ CCO_IMAGE=$(oc adm release info --image-for='cloud-credential-operator'
$RELEASE_IMAGE -a ~/.pull-secret)
```

NOTE

Ensure that the architecture of the **$RELEASE_IMAGE** matches the architecture of the environment in which you will use the **ccoctl** tool.

3. Extract the **ccoctl** binary from the CCO container image within the OpenShift Container Platform release image by running the following command:

```
$ oc image extract $CCO_IMAGE --file="/usr/bin/ccoctl" -a ~/.pull-secret
```

4. Change the permissions to make **ccoctl** executable by running the following command:

```
$ chmod 775 ccoctl
```

Verification

- To verify that **ccoctl** is ready to use, display the help file by running the following command:

```
$ ccoctl --help
```

Output of ccoctl --help

```
OpenShift credentials provisioning tool

Usage:
  ccoctl [command]

Available Commands:
  alibabacloud Manage credentials objects for alibaba cloud
  aws          Manage credentials objects for AWS cloud
  gcp          Manage credentials objects for Google cloud
  help         Help about any command
  ibmcloud     Manage credentials objects for IBM Cloud
  nutanix      Manage credentials objects for Nutanix

Flags:
  -h, --help   help for ccoctl

Use "ccoctl [command] --help" for more information about a command.
```

Additional resources

- Rotating API keys for IBM Cloud VPC

9.3.3. Next steps

- Installing a cluster on IBM Cloud VPC with customizations

9.3.4. Additional resources

- Preparing to update a cluster with manually maintained credentials

9.4. INSTALLING A CLUSTER ON IBM CLOUD VPC WITH CUSTOMIZATIONS

In OpenShift Container Platform version 4.11, you can install a customized cluster on infrastructure that the installation program provisions on IBM Cloud VPC. To customize the installation, you modify parameters in the **install-config.yaml** file before you install the cluster.

IMPORTANT

IBM Cloud VPC using installer-provisioned infrastructure is a Technology Preview feature only. Technology Preview features are not supported with Red Hat production service level agreements (SLAs) and might not be functionally complete. Red Hat does not recommend using them in production. These features provide early access to upcoming product features, enabling customers to test functionality and provide feedback during the development process.

For more information about the support scope of Red Hat Technology Preview features, see Technology Preview Features Support Scope .

9.4.1. Prerequisites

- You reviewed details about the OpenShift Container Platform installation and update processes.
- You read the documentation on selecting a cluster installation method and preparing it for users.
- You configured an IBM Cloud account to host the cluster.
- If you use a firewall, you configured it to allow the sites that your cluster requires access to.
- You configured the **ccoctl** utility before you installed the cluster. For more information, see Configuring IAM for IBM Cloud VPC.

9.4.2. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.11, you require access to the internet to install your cluster.

You must have internet access to:

- Access OpenShift Cluster Manager Hybrid Cloud Console to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access Quay.io to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.

IMPORTANT

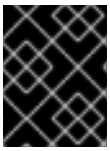
If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

9.4.3. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the **~/.ssh/authorized_keys** list for the **core** user on each node, which enables password-less authentication.

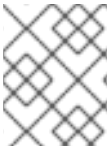
After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The **./openshift-install gather** command also requires the SSH public key to be in place on the cluster nodes.



IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.



NOTE

You must use a local key, not one that you configured with platform-specific approaches such as AWS key pairs.

Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N '' -f <path>/<file_name>
```
(1)

(1) Specify the path and file name, such as **~/.ssh/id_ed25519**, of the new SSH key. If you have an existing key pair, ensure your public key is in the your **~/.ssh** directory.

NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS validated or Modules In Process cryptographic libraries on the **x86_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the ~/**.ssh/id_ed25519.pub** public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the **./openshift-install gather** command.

NOTE

On some distributions, default SSH private key identities such as ~/**.ssh/id_rsa** and ~/**.ssh/id_dsa** are managed automatically.

a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

Example output

```
Agent pid 31874
```

NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

1 Specify the path and file name for your SSH private key, such as ~/**.ssh/id_ed25519**

Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

9.4.4. Obtaining the installation program

Before you install OpenShift Container Platform, download the installation file on a local computer.

Prerequisites

- You have a computer that runs Linux or macOS, with 500 MB of local disk space.

Procedure

1. Access the Infrastructure Provider page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program that corresponds with your host operating system and architecture, and place the file in the directory where you will store the installation configuration files.

IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.

IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation pull secret from the Red Hat OpenShift Cluster Manager . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

9.4.5. Exporting the IBM Cloud VPC API key

You must set the IBM Cloud VPC API key you created as a global variable; the installation program ingests the variable during startup to set the API key.

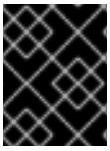
Prerequisties

- You have created either a user API key or service ID API key for your IBM Cloud account.

Procedure

- Export your IBM Cloud VPC API key as a global variable:

```
$ export IC_API_KEY=<api_key>
```



IMPORTANT

You must set the variable name exactly as specified; the installation program expects the variable name to be present during startup.

9.4.6. Creating the installation configuration file

You can customize the OpenShift Container Platform cluster you install on IBM Cloud.

Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.
- Obtain service principal permissions at the subscription level.

Procedure

1. Create the **install-config.yaml** file.
   a. Change to the directory that contains the installation program and run the following command:

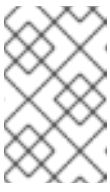
```
$ ./openshift-install create install-config --dir <installation_directory> 1
```

1 For **<installation_directory>**, specify the directory name to store the files that the installation program creates.

When specifying the directory:

- Verify that the directory has the **execute** permission. This permission is required to run Terraform binaries under the installation directory.
- Use an empty directory. Some installation assets, such as bootstrap X.509 certificates, have short expiration intervals, therefore you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

   b. At the prompts, provide the configuration details for your cloud:
      i. Optional: Select an SSH key to use to access your cluster machines.



NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

      ii. Select **ibmcloud** as the platform to target.
      iii. Select the region to deploy the cluster to.

iv. Select the base domain to deploy the cluster to. The base domain corresponds to the public DNS zone that you created for your cluster.

v. Enter a descriptive name for your cluster.

vi. Paste the pull secret from the Red Hat OpenShift Cluster Manager .

2. Modify the **install-config.yaml** file. You can find more information about the available parameters in the "Installation configuration parameters" section.

3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.

IMPORTANT

The **install-config.yaml** file is consumed during the installation process. If you want to reuse the file, you must back it up now.

9.4.6.1. Installation configuration parameters

Before you deploy an OpenShift Container Platform cluster, you provide parameter values to describe your account on the cloud platform that hosts your cluster and optionally customize your cluster's platform. When you create the **install-config.yaml** installation configuration file, you provide values for the required parameters through the command line. If you customize your cluster, you can modify the **install-config.yaml** file to provide more details about the platform.

NOTE

After installation, you cannot modify these parameters in the **install-config.yaml** file.

9.4.6.1.1. Required configuration parameters

Required installation configuration parameters are described in the following table:

Table 9.3. Required parameters

Parameter	Description	Values
apiVersion	The API version for the **install-config.yaml** content. The current version is **v1**. The installer may also support older API versions.	String

Parameter	Description	Values
baseDomain	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the **baseDomain** and **metadata.name** parameter values that uses the **<metadata.name>.<baseDomain>** format.	A fully-qualified domain or subdomain name, such as **example.com**.
metadata	Kubernetes resource **ObjectMeta**, from which only the **name** parameter is consumed.	Object
metadata.name	The name of the cluster. DNS records for the cluster are all subdomains of **{{.metadata.name}}.{{.baseDomain}}**.	String of lowercase letters, hyphens (**-**), and periods (**.**), such as **dev**.
platform	The configuration for the specific platform upon which to perform the installation: **alibabacloud**, **aws**, **baremetal**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**. For additional information about **platform.<platform>** parameters, consult the table for your specific platform that follows.	Object

Parameter	Description	Values
pullSecret	Get a pull secret from the Red Hat OpenShift Cluster Manager to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	<pre>{ "auths":{ "cloud.openshift.com":{ "auth":"b3Blb=", "email":"you@example.com" }, "quay.io":{ "auth":"b3Blb=", "email":"you@example.com" } } }</pre>

9.4.6.1.2. Network configuration parameters

You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

Only IPv4 addresses are supported.

NOTE

Globalnet is not supported with Red Hat OpenShift Data Foundation disaster recovery solutions. For regional disaster recovery scenarios, ensure that you use a nonoverlapping range of private IP addresses for the cluster and service networks in each cluster.

Table 9.4. Network parameters

Parameter	Description	Values
networking	The configuration for the cluster network.	Object  **NOTE** You cannot modify parameters specified by the **networking** object after installation.

Parameter	Description	Values
networking.networkType	The cluster network provider Container Network Interface (CNI) cluster network provider to install.	Either **OpenShiftSDN** or **OVNKubernetes**. **OpenShiftSDN** is a CNI provider for all-Linux networks. **OVNKubernetes** is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is **OpenShiftSDN**.
networking.clusterNetwork	The IP address blocks for pods. The default value is **10.128.0.0/14** with a host prefix of **/23**. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: `networking:` `  clusterNetwork:` `  - cidr: 10.128.0.0/14` `    hostPrefix: 23`
networking.clusterNetwork.cidr	Required if you use **networking.clusterNetwork**. An IP address block. An IPv4 network.	An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between **0** and **32**.
networking.clusterNetwork.hostPrefix	The subnet prefix length to assign to each individual node. For example, if **hostPrefix** is set to **23** then each node is assigned a **/23** subnet out of the given **cidr**. A **hostPrefix** value of **23** provides 510 (2^(32 - 23) - 2) pod IP addresses.	A subnet prefix. The default value is **23**.
networking.serviceNetwork	The IP address block for services. The default value is **172.30.0.0/16**. The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.	An array with an IP address block in CIDR format. For example: `networking:` `  serviceNetwork:` `  - 172.30.0.0/16`
networking.machineNetwork	The IP address blocks for machines. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: `networking:` `  machineNetwork:` `  - cidr: 10.0.0.0/16`

Parameter	Description	Values
networking.machineNetwork.cidr	Required if you use **networking.machineNetwork**. An IP address block. The default value is **10.0.0.0/16** for all platforms other than libvirt. For libvirt, the default value is **192.168.126.0/24**.	An IP network block in CIDR notation. For example, **10.0.0.0/16**.  **NOTE** Set the **networking.machineNetwork** to match the CIDR that the preferred NIC resides in.

9.4.6.1.3. Optional configuration parameters

Optional installation configuration parameters are described in the following table:

Table 9.5. Optional parameters

Parameter	Description	Values
additionalTrustBundle	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String
capabilities	Controls the installation of optional core cluster components. You can reduce the footprint of your OpenShift Container Platform cluster by disabling optional components.	String array
capabilities.baselineCapabilitySet	Selects an initial set of optional capabilities to enable. Valid values are **None**, **v4.11** and **vCurrent**. **v4.11** enables the **baremetal** Operator, the **marketplace** Operator, and the **openshift-samples** content. **vCurrent** installs the recommended set of capabilities for the current version of OpenShift Container Platform. The default value is **vCurrent**.	String

Parameter	Description	Values
capabilities.additionalEnabledCapabilities	Extends the set of optional capabilities beyond what you specify in **baselineCapabilitySet**. Valid values are **baremetal**, **marketplace** and **openshift-samples**. You may specify multiple capabilities in this parameter.	String array
cgroupsV2	Enables Linux control groups version 2 (cgroups v2) on specific nodes in your cluster. The OpenShift Container Platform process for enabling cgroups v2 disables all cgroup version 1 controllers and hierarchies. The OpenShift Container Platform cgroups version 2 feature is in Developer Preview and is not supported by Red Hat at this time.	**true**
compute	The configuration for the machines that comprise the compute nodes.	Array of **MachinePool** objects.
compute.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** (the default).	String
compute.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  IMPORTANT If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
compute.name	Required if you use **compute**. The name of the machine pool.	**worker**

Parameter	Description	Values
compute.platform	Required if you use **compute**. Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the **controlPlane.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
compute.replicas	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to **2**. The default value is **3**.
controlPlane	The configuration for the machines that comprise the control plane.	Array of **MachinePool** objects.
controlPlane.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** (the default).	String
controlPlane.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  IMPORTANT If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
controlPlane.name	Required if you use **controlPlane**. The name of the machine pool.	**master**

Parameter	Description	Values
controlPlane.platform	Required if you use **controlPlane**. Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the **compute.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
controlPlane.replicas	The number of control plane machines to provision.	The only supported value is **3**, which is the default value.
credentialsMode	The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported.  **NOTE** Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the *Cloud Credential Operator* entry in the *Cluster Operators reference* content.  **NOTE** If your AWS account has service control policies (SCP) enabled, you must configure the **credentialsMode** parameter to **Mint**, **Passthrough** or **Manual**.	**Mint**, **Passthrough**, **Manual** or an empty string (**""**).

Parameter	Description	Values
fips	Enable or disable FIPS mode. The default is **false** (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.  **IMPORTANT** To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.  **NOTE** If you are using Azure File storage, you cannot enable FIPS mode.	**false** or **true**
imageContentSources	Sources and repositories for the release-image content.	Array of objects. Includes a **source** and, optionally, **mirrors**, as described in the following rows of this table.
imageContentSources.source	Required if you use **imageContentSources**. Specify the repository that users refer to, for example, in image pull specifications.	String

Parameter	Description	Values
imageContentSources.mirrors	Specify one or more repositories that may also contain the same images.	Array of strings
publish	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	**Internal** or **External**. To deploy a private cluster, which cannot be accessed from the internet, set **publish** to **Internal**. The default value is **External**.
sshKey	The SSH key to authenticate access to your cluster machines.  **NOTE** For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.	For example, **sshKey: ssh-ed25519 AAAA..**.

9.4.6.1.4. Additional IBM Cloud VPC configuration parameters

Additional IBM Cloud VPC configuration parameters are described in the following table:

Table 9.6. Additional IBM Cloud VPC parameters

Parameter	Description	Values
platform.ibmcloud.resourceGroupName	The name of an existing resource group to install your cluster to. This resource group must only be used for this specific cluster because the cluster components assume ownership of all of the resources in the resource group. If undefined, a new resource group is created for the cluster. [1]	String, for example **existing_resource_group**.
platform.ibmcloud.dedicatedHosts.profile	The new dedicated host to create. If you specify a value for **platform.ibmcloud.dedicatedHosts.name**, this parameter is not required.	Valid IBM Cloud VPC dedicated host profile, such as **cx2-host-152x304**. [2]

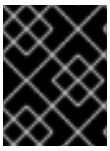
Parameter	Description	Values
platform.ibmcloud.dedicatedHosts.name	An existing dedicated host. If you specify a value for **platform.ibmcloud.dedicatedHosts.profile**, this parameter is not required.	String, for example **my-dedicated-host-name**.
platform.ibmcloud.type	The instance type for all IBM Cloud VPC machines.	Valid IBM Cloud VPC instance type, such as **bx2-8x32**. [2]

1. Whether you define an existing resource group, or if the installer creates one, determines how the resource group is treated when the cluster is uninstalled. If you define a resource group, the installer removes all of the installer-provisioned resources, but leaves the resource group alone; if a resource group is created as part of the installation, the installer removes all of the installer provisioned resources and the resource group.

2. To determine which profile best meets your needs, see Instance Profiles in the IBM documentation.

9.4.6.2. Sample customized install-config.yaml file for IBM Cloud VPC

You can customize the **install-config.yaml** file to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.



IMPORTANT

This sample YAML file is provided for reference only. You must obtain your **install-config.yaml** file by using the installation program and modify it.

```
apiVersion: v1
baseDomain: example.com (1)
controlPlane: (2) (3)
  hyperthreading: Enabled (4)
  name: master
  platform:
    ibmcloud: {}
  replicas: 3
compute: (5) (6)
- hyperthreading: Enabled (7)
  name: worker
  platform:
    ibmcloud: {}
  replicas: 3
metadata:
```

```
  name: test-cluster 8
networking:
  clusterNetwork:
  - cidr: 10.128.0.0/14
    hostPrefix: 23
  machineNetwork:
  - cidr: 10.0.0.0/16
  networkType: OpenShiftSDN
  serviceNetwork:
  - 172.30.0.0/16
platform:
  ibmcloud:
    region: us-south 9
credentialsMode: Manual
publish: External
pullSecret: '{"auths": ...}' 10
fips: false 11
sshKey: ssh-ed25519 AAAA... 12
```

1 8 9 10 Required. The installation program prompts you for this value.

2 5 If you do not provide these parameters and values, the installation program provides the default value.

3 6 The **controlPlane** section is a single mapping, but the **compute** section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, **-**, and the first line of the **controlPlane** section must not. Only one control plane pool is used.

4 7 Whether to enable or disable simultaneous multithreading, or **hyperthreading**. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores. You can disable it by setting the parameter value to **Disabled**. If you disable simultaneous multithreading in some cluster machines, you must disable it in all cluster machines.

IMPORTANT

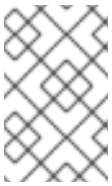
If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance. Use larger machine types, such as **n1-standard-8**, for your machines if you disable simultaneous multithreading.

11 Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.

IMPORTANT

To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS Validated or Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.

12 You can optionally provide the **sshKey** value that you use to access the machines in your cluster.



NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

9.4.6.3. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.

NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
```

1 A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.

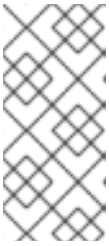
2 A proxy URL to use for creating HTTPS connections outside the cluster.

3 A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use * to bypass the proxy for all destinations.

4 If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace that contains one or more additional CA certificates that are required for proxying HTTPS connections. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges these contents with the Red Hat Enterprise Linux CoreOS (RHCOS) trust bundle, and this config map is referenced in the **trustedCA** field of the **Proxy** object. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.

NOTE

The installation program does not support the proxy **readinessEndpoints** field.



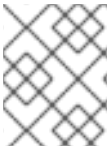
NOTE

If the installer times out, restart and then complete the deployment by using the **wait-for** command of the installer. For example:

```
$ ./openshift-install wait-for install-complete --log-level debug
```

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.



NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

9.4.7. Manually creating IAM for IBM Cloud VPC

Installing the cluster requires that the Cloud Credential Operator (CCO) operate in manual mode. While the installation program configures the CCO for manual mode, you must specify the identity and access management secrets for you cloud provider.

You can use the Cloud Credential Operator (CCO) utility (**ccoctl**) to create the required IBM Cloud VPC resources.

Prerequisites

- You have configured the **ccoctl** binary.
- You have an existing **install-config.yaml** file.

Procedure

1. Edit the **install-config.yaml** configuration file so that it contains the **credentialsMode** parameter set to **Manual**.

   Example install-config.yaml configuration file

   ```
   apiVersion: v1
   baseDomain: cluster1.example.com
   credentialsMode: Manual (1)
   compute:
   - architecture: amd64
     hyperthreading: Enabled
   ...
   ```

   (1) This line is added to set the **credentialsMode** parameter to **Manual**.

2. To generate the manifests, run the following command from the directory that contains the installation program:

   ```
   $ openshift-install create manifests --dir <installation_directory>
   ```

3. From the directory that contains the installation program, obtain the OpenShift Container Platform release image that your **openshift-install** binary is built to use:

   ```
   $ RELEASE_IMAGE=$(./openshift-install version | awk '/release image/ {print $3}')
   ```

4. Extract the **CredentialsRequest** objects from the OpenShift Container Platform release image:

   ```
   $ oc adm release extract --cloud=ibmcloud --credentials-requests $RELEASE_IMAGE \
       --to=<path_to_credential_requests_directory> (1)
   ```

   (1) The directory where the credential requests will be stored.

   This command creates a YAML file for each **CredentialsRequest** object.

   Sample CredentialsRequest object

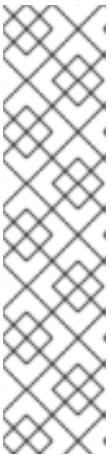
   ```
   apiVersion: cloudcredential.openshift.io/v1
   kind: CredentialsRequest
   metadata:
     labels:
       controller-tools.k8s.io: "1.0"
     name: openshift-image-registry-ibmcos
     namespace: openshift-cloud-credential-operator
   spec:
     secretRef:
       name: installer-cloud-credentials
       namespace: openshift-image-registry
     providerSpec:
       apiVersion: cloudcredential.openshift.io/v1
       kind: IBMCloudProviderSpec
       policies:
   ```

```
    - attributes:
      - name: serviceName
        value: cloud-object-storage
      roles:
      - crn:v1:bluemix:public:iam::::role:Viewer
      - crn:v1:bluemix:public:iam::::role:Operator
      - crn:v1:bluemix:public:iam::::role:Editor
      - crn:v1:bluemix:public:iam::::serviceRole:Reader
      - crn:v1:bluemix:public:iam::::serviceRole:Writer
    - attributes:
      - name: resourceType
        value: resource-group
      roles:
      - crn:v1:bluemix:public:iam::::role:Viewer
```

5. Create the service ID for each credential request, assign the policies defined, create an API key in IBM Cloud VPC, and generate the secret:

```
$ ccoctl ibmcloud create-service-id \
  --credentials-requests-dir <path_to_store_credential_request_templates> \ 1
  --name <cluster_name> \ 2
  --output-dir <installation_directory> \
  --resource-group-name <resource_group_name> 3
```

1. The directory where the credential requests are stored.
2. The name of the OpenShift Container Platform cluster.
3. Optional: The name of the resource group used for scoping the access policies.



NOTE

If your cluster uses Technology Preview features that are enabled by the **TechPreviewNoUpgrade** feature set, you must include the **--enable-tech-preview** parameter.

If an incorrect resource group name is provided, the installation fails during the bootstrap phase. To find the correct resource group name, run the following command:

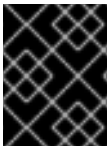
```
$ grep resourceGroupName <installation_directory>/manifests/cluster-infrastructure-02-config.yml
```

Verification

- Ensure that the appropriate secrets were generated in your cluster's **manifests** directory.

9.4.8. Deploying the cluster

You can install OpenShift Container Platform on a compatible cloud platform.



IMPORTANT

You can run the **create cluster** command of the installation program only once, during initial installation.

Prerequisites

- Configure an account with the cloud platform that hosts your cluster.
- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.

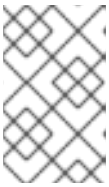
Procedure

- Change to the directory that contains the installation program and initialize the cluster deployment:

```
$ ./openshift-install create cluster --dir <installation_directory> \ 1
    --log-level=info 2
```

1 For **<installation_directory>**, specify the location of your customized **./install-config.yaml** file.

2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.



NOTE

If the cloud provider account that you configured on your host does not have sufficient permissions to deploy the cluster, the installation process stops, and the missing permissions are displayed.

Verification

When the cluster deployment completes successfully:

- The terminal displays directions for accessing your cluster, including a link to the web console and credentials for the **kubeadmin** user.
- Credential information also outputs to **<installation_directory>/.openshift_install.log**.

IMPORTANT

Do not delete the installation program or the files that the installation program creates. Both are required to delete the cluster.

Example output

```
...
INFO Install complete!
INFO To access the cluster as the system:admin user when using 'oc', run 'export
KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
INFO Access the OpenShift web-console here: https://console-openshift-
```

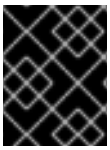
```
console.apps.mycluster.example.com
INFO Login to the console with user: "kubeadmin", and password: "password"
INFO Time elapsed: 36m22s
```

IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

9.4.9. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.



IMPORTANT

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.11. Download and install the new version of **oc**.

Installing the OpenShift CLI on Linux

You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the architecture in the **Product Variant** drop-down menu.
3. Select the appropriate version in the **Version** drop-down menu.
4. Click **Download Now** next to the **OpenShift v4.11 Linux Client** entry and save the file.
5. Unpack the archive:

   ```
   $ tar xvf <file>
   ```

6. Place the **oc** binary in a directory that is on your **PATH**.
   To check your **PATH**, execute the following command:

   ```
   $ echo $PATH
   ```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.
   To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
C:\> oc <command>
```

Installing the OpenShift CLI on macOS

You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 macOS Client** entry and save the file.

NOTE

For macOS arm64, choose the **OpenShift v4.11 macOS arm64 Client** entry.

4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your PATH.
   To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

9.4.10. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

Example output

```
system:admin
```

Additional resources

- Accessing the web console

9.4.11. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.11, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to OpenShift Cluster Manager Hybrid Cloud Console.

After you confirm that your OpenShift Cluster Manager Hybrid Cloud Console inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, use subscription watch to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

Additional resources

- About remote health monitoring

9.4.12. Next steps

- Customize your cluster.
- If necessary, you can opt out of remote health reporting .

9.5. INSTALLING A CLUSTER ON IBM CLOUD VPC WITH NETWORK CUSTOMIZATIONS

In OpenShift Container Platform version 4.11, you can install a cluster with a customized network configuration on infrastructure that the installation program provisions on IBM Cloud VPC. By customizing your network configuration, your cluster can coexist with existing IP address allocations in your environment and integrate with existing MTU and VXLAN configurations. To customize the installation, you modify parameters in the **install-config.yaml** file before you install the cluster.

You must set most of the network configuration parameters during installation, and you can modify only **kubeProxy** configuration parameters in a running cluster.

IMPORTANT

IBM Cloud VPC using installer-provisioned infrastructure is a Technology Preview feature only. Technology Preview features are not supported with Red Hat production service level agreements (SLAs) and might not be functionally complete. Red Hat does not recommend using them in production. These features provide early access to upcoming product features, enabling customers to test functionality and provide feedback during the development process.

For more information about the support scope of Red Hat Technology Preview features, see Technology Preview Features Support Scope .

9.5.1. Prerequisites

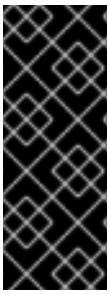
- You reviewed details about the OpenShift Container Platform installation and update processes.
- You read the documentation on selecting a cluster installation method and preparing it for users.
- You configured an IBM Cloud account to host the cluster.
- If you use a firewall, you configured it to allow the sites that your cluster requires access to.
- You configured the **ccoctl** utility before you installed the cluster. For more information, see Configuring IAM for IBM Cloud VPC.

9.5.2. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.11, you require access to the internet to install your cluster.

You must have internet access to:

- Access OpenShift Cluster Manager Hybrid Cloud Console to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access Quay.io to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.



IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

9.5.3. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the **~/.ssh/authorized_keys** list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The **./openshift-install gather** command also requires the SSH public key to be in place on the cluster nodes.

IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.

NOTE

You must use a local key, not one that you configured with platform-specific approaches such as AWS key pairs.

Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N '' -f <path>/<file_name> 1
```

1 Specify the path and file name, such as **~/.ssh/id_ed25519**, of the new SSH key. If you have an existing key pair, ensure your public key is in the your **~/.ssh** directory.

NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS validated or Modules In Process cryptographic libraries on the **x86_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the ~/**.ssh/id_ed25519.pub** public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the **./openshift-install gather** command.

NOTE

On some distributions, default SSH private key identities such as ~/**.ssh/id_rsa** and ~/**.ssh/id_dsa** are managed automatically.

a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

Example output

```
Agent pid 31874
```

NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> (1)
```

(1) Specify the path and file name for your SSH private key, such as ~/**.ssh/id_ed25519**

Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

9.5.4. Obtaining the installation program

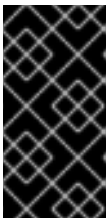
Before you install OpenShift Container Platform, download the installation file on a local computer.

Prerequisites

- You have a computer that runs Linux or macOS, with 500 MB of local disk space.

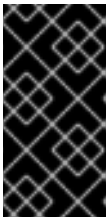
Procedure

1. Access the Infrastructure Provider page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program that corresponds with your host operating system and architecture, and place the file in the directory where you will store the installation configuration files.



IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.



IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation pull secret from the Red Hat OpenShift Cluster Manager . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

9.5.5. Exporting the IBM Cloud VPC API key

You must set the IBM Cloud VPC API key you created as a global variable; the installation program ingests the variable during startup to set the API key.

Prerequisties

- You have created either a user API key or service ID API key for your IBM Cloud account.

Procedure

- Export your IBM Cloud VPC API key as a global variable:

```
$ export IC_API_KEY=<api_key>
```

IMPORTANT

You must set the variable name exactly as specified; the installation program expects the variable name to be present during startup.

9.5.6. Creating the installation configuration file

You can customize the OpenShift Container Platform cluster you install on IBM Cloud.

Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.
- Obtain service principal permissions at the subscription level.

Procedure

1. Create the **install-config.yaml** file.
   a. Change to the directory that contains the installation program and run the following command:

```
$ ./openshift-install create install-config --dir <installation_directory> 1
```

1 For **<installation_directory>**, specify the directory name to store the files that the installation program creates.

When specifying the directory:

- Verify that the directory has the **execute** permission. This permission is required to run Terraform binaries under the installation directory.
- Use an empty directory. Some installation assets, such as bootstrap X.509 certificates, have short expiration intervals, therefore you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

   b. At the prompts, provide the configuration details for your cloud:
      i. Optional: Select an SSH key to use to access your cluster machines.

NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

ii. Select **ibmcloud** as the platform to target.

iii. Select the region to deploy the cluster to.

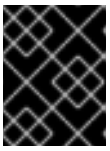
iv. Select the base domain to deploy the cluster to. The base domain corresponds to the public DNS zone that you created for your cluster.

v. Enter a descriptive name for your cluster.

vi. Paste the pull secret from the Red Hat OpenShift Cluster Manager .

2. Modify the **install-config.yaml** file. You can find more information about the available parameters in the "Installation configuration parameters" section.

3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.



IMPORTANT

The **install-config.yaml** file is consumed during the installation process. If you want to reuse the file, you must back it up now.

9.5.6.1. Installation configuration parameters

Before you deploy an OpenShift Container Platform cluster, you provide parameter values to describe your account on the cloud platform that hosts your cluster and optionally customize your cluster's platform. When you create the **install-config.yaml** installation configuration file, you provide values for the required parameters through the command line. If you customize your cluster, you can modify the **install-config.yaml** file to provide more details about the platform.

NOTE

After installation, you cannot modify these parameters in the **install-config.yaml** file.

9.5.6.1.1. Required configuration parameters

Required installation configuration parameters are described in the following table:

Table 9.7. Required parameters

Parameter	Description	Values
apiVersion	The API version for the **install-config.yaml** content. The current version is **v1**. The installer may also support older API versions.	String

Parameter	Description	Values
baseDomain	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the **baseDomain** and **metadata.name** parameter values that uses the **<metadata.name>.<baseDomain>** format.	A fully-qualified domain or subdomain name, such as **example.com**.
metadata	Kubernetes resource **ObjectMeta**, from which only the **name** parameter is consumed.	Object
metadata.name	The name of the cluster. DNS records for the cluster are all subdomains of **{{.metadata.name}}.{{.baseDomain}}**.	String of lowercase letters, hyphens (**-**), and periods (**.**), such as **dev**.
platform	The configuration for the specific platform upon which to perform the installation: **alibabacloud**, **aws**, **baremetal**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**. For additional information about **platform.<platform>** parameters, consult the table for your specific platform that follows.	Object

Parameter	Description	Values
pullSecret	Get a pull secret from the Red Hat OpenShift Cluster Manager to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	<pre>{ "auths":{ "cloud.openshift.com":{ "auth":"b3Blb=", "email":"you@example.com" }, "quay.io":{ "auth":"b3Blb=", "email":"you@example.com" } } }</pre>

9.5.6.1.2. Network configuration parameters

You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

Only IPv4 addresses are supported.

NOTE

Globalnet is not supported with Red Hat OpenShift Data Foundation disaster recovery solutions. For regional disaster recovery scenarios, ensure that you use a nonoverlapping range of private IP addresses for the cluster and service networks in each cluster.

Table 9.8. Network parameters

Parameter	Description	Values
networking	The configuration for the cluster network.	Object  **NOTE** You cannot modify parameters specified by the **networking** object after installation.

Parameter	Description	Values
networking.networkType	The cluster network provider Container Network Interface (CNI) cluster network provider to install.	Either **OpenShiftSDN** or **OVNKubernetes**. **OpenShiftSDN** is a CNI provider for all-Linux networks. **OVNKubernetes** is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is **OpenShiftSDN**.
networking.clusterNetwork	The IP address blocks for pods. The default value is **10.128.0.0/14** with a host prefix of **/23**. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: `networking:` `  clusterNetwork:` `  - cidr: 10.128.0.0/14` `  hostPrefix: 23`
networking.clusterNetwork.cidr	Required if you use **networking.clusterNetwork**. An IP address block. An IPv4 network.	An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between **0** and **32**.
networking.clusterNetwork.hostPrefix	The subnet prefix length to assign to each individual node. For example, if **hostPrefix** is set to **23** then each node is assigned a **/23** subnet out of the given **cidr**. A **hostPrefix** value of **23** provides 510 (2^(32 - 23) - 2) pod IP addresses.	A subnet prefix. The default value is **23**.
networking.serviceNetwork	The IP address block for services. The default value is **172.30.0.0/16**. The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.	An array with an IP address block in CIDR format. For example: `networking:` `  serviceNetwork:` `  - 172.30.0.0/16`
networking.machineNetwork	The IP address blocks for machines. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: `networking:` `  machineNetwork:` `  - cidr: 10.0.0.0/16`

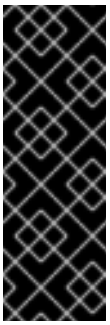
Parameter	Description	Values
networking.machineNetwork.cidr	Required if you use **networking.machineNetwork**. An IP address block. The default value is **10.0.0.0/16** for all platforms other than libvirt. For libvirt, the default value is **192.168.126.0/24**.	An IP network block in CIDR notation. For example, **10.0.0.0/16**.  **NOTE** Set the **networking.machineNetwork** to match the CIDR that the preferred NIC resides in.

9.5.6.1.3. Optional configuration parameters

Optional installation configuration parameters are described in the following table:

Table 9.9. Optional parameters

Parameter	Description	Values
additionalTrustBundle	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String
capabilities	Controls the installation of optional core cluster components. You can reduce the footprint of your OpenShift Container Platform cluster by disabling optional components.	String array
capabilities.baselineCapabilitySet	Selects an initial set of optional capabilities to enable. Valid values are **None**, **v4.11** and **vCurrent**. **v4.11** enables the **baremetal** Operator, the **marketplace** Operator, and the **openshift-samples** content. **vCurrent** installs the recommended set of capabilities for the current version of OpenShift Container Platform. The default value is **vCurrent**.	String

Parameter	Description	Values
capabilities.additionalEnabledCapabilities	Extends the set of optional capabilities beyond what you specify in **baselineCapabilitySet**. Valid values are **baremetal**, **marketplace** and **openshift-samples**. You may specify multiple capabilities in this parameter.	String array
cgroupsV2	Enables Linux control groups version 2 (cgroups v2) on specific nodes in your cluster. The OpenShift Container Platform process for enabling cgroups v2 disables all cgroup version 1 controllers and hierarchies. The OpenShift Container Platform cgroups version 2 feature is in Developer Preview and is not supported by Red Hat at this time.	**true**
compute	The configuration for the machines that comprise the compute nodes.	Array of **MachinePool** objects.
compute.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** (the default).	String
compute.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  IMPORTANT If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
compute.name	Required if you use **compute**. The name of the machine pool.	**worker**

Parameter	Description	Values
compute.platform	Required if you use **compute**. Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the **controlPlane.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
compute.replicas	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to **2**. The default value is **3**.
controlPlane	The configuration for the machines that comprise the control plane.	Array of **MachinePool** objects.
controlPlane.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** (the default).	String
controlPlane.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  IMPORTANT If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
controlPlane.name	Required if you use **controlPlane**. The name of the machine pool.	**master**

Parameter	Description	Values
controlPlane.platform	Required if you use **controlPlane**. Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the **compute.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
controlPlane.replicas	The number of control plane machines to provision.	The only supported value is **3**, which is the default value.
credentialsMode	The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported.  **NOTE** Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the *Cloud Credential Operator* entry in the *Cluster Operators reference* content.  **NOTE** If your AWS account has service control policies (SCP) enabled, you must configure the **credentialsMode** parameter to **Mint**, **Passthrough** or **Manual**.	**Mint**, **Passthrough**, **Manual** or an empty string (**""**).

Parameter	Description	Values
fips	Enable or disable FIPS mode. The default is **false** (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.  **IMPORTANT** To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.  **NOTE** If you are using Azure File storage, you cannot enable FIPS mode.	**false** or **true**
imageContentSources	Sources and repositories for the release-image content.	Array of objects. Includes a **source** and, optionally, **mirrors**, as described in the following rows of this table.
imageContentSources.source	Required if you use **imageContentSources**. Specify the repository that users refer to, for example, in image pull specifications.	String

Parameter	Description	Values
imageContentSources.mirrors	Specify one or more repositories that may also contain the same images.	Array of strings
publish	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	**Internal** or **External**. To deploy a private cluster, which cannot be accessed from the internet, set **publish** to **Internal**. The default value is **External**.
sshKey	The SSH key to authenticate access to your cluster machines.  **NOTE** For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.	For example, **sshKey: ssh-ed25519 AAAA..**.

9.5.6.1.4. Additional IBM Cloud VPC configuration parameters

Additional IBM Cloud VPC configuration parameters are described in the following table:

Table 9.10. Additional IBM Cloud VPC parameters

Parameter	Description	Values
platform.ibmcloud.resourceGroupName	The name of an existing resource group to install your cluster to. This resource group must only be used for this specific cluster because the cluster components assume ownership of all of the resources in the resource group. If undefined, a new resource group is created for the cluster. [1]	String, for example **existing_resource_group**.
platform.ibmcloud.dedicatedHosts.profile	The new dedicated host to create. If you specify a value for **platform.ibmcloud.dedicatedHosts.name**, this parameter is not required.	Valid IBM Cloud VPC dedicated host profile, such as **cx2-host-152x304**. [2]

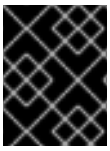
Parameter	Description	Values
platform.ibmcloud.dedicatedHosts.name	An existing dedicated host. If you specify a value for **platform.ibmcloud.dedicatedHosts.profile**, this parameter is not required.	String, for example **my-dedicated-host-name**.
platform.ibmcloud.type	The instance type for all IBM Cloud VPC machines.	Valid IBM Cloud VPC instance type, such as **bx2-8x32**. [2]

1. Whether you define an existing resource group, or if the installer creates one, determines how the resource group is treated when the cluster is uninstalled. If you define a resource group, the installer removes all of the installer-provisioned resources, but leaves the resource group alone; if a resource group is created as part of the installation, the installer removes all of the installer provisioned resources and the resource group.

2. To determine which profile best meets your needs, see Instance Profiles in the IBM documentation.

9.5.6.2. Sample customized install-config.yaml file for IBM Cloud VPC

You can customize the **install-config.yaml** file to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.



IMPORTANT

This sample YAML file is provided for reference only. You must obtain your **install-config.yaml** file by using the installation program and modify it.

```
apiVersion: v1
baseDomain: example.com (1)
controlPlane: (2) (3)
  hyperthreading: Enabled (4)
  name: master
  platform:
    ibmcloud: {}
  replicas: 3
compute: (5) (6)
- hyperthreading: Enabled (7)
  name: worker
  platform:
    ibmcloud: {}
  replicas: 3
metadata:
```

```
  name: test-cluster 8
networking:
networking: 9
  clusterNetwork:
  - cidr: 10.128.0.0/14
    hostPrefix: 23
  machineNetwork:
  - cidr: 10.0.0.0/16
  networkType: OpenShiftSDN
  serviceNetwork:
  - 172.30.0.0/16
platform:
  ibmcloud:
    region: us-south 10
credentialsMode: Manual
publish: External
pullSecret: '{"auths": ...}' 11
fips: false 12
sshKey: ssh-ed25519 AAAA... 13
```

1 8 10 11 Required. The installation program prompts you for this value.

2 5 9 If you do not provide these parameters and values, the installation program provides the default value.

3 6 The **controlPlane** section is a single mapping, but the **compute** section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, **-**, and the first line of the **controlPlane** section must not. Only one control plane pool is used.

4 7 Whether to enable or disable simultaneous multithreading, or **hyperthreading**. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores. You can disable it by setting the parameter value to **Disabled**. If you disable simultaneous multithreading in some cluster machines, you must disable it in all cluster machines.

IMPORTANT

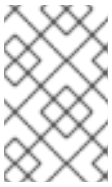
If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance. Use larger machine types, such as **n1-standard-8**, for your machines if you disable simultaneous multithreading.

12 Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.

IMPORTANT

To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS Validated or Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.

13 You can optionally provide the **sshKey** value that you use to access the machines in your cluster.



NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

9.5.6.3. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.

NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
```

```
additionalTrustBundle: | 4
  -----BEGIN CERTIFICATE-----
  <MY_TRUSTED_CA_CERT>
  -----END CERTIFICATE-----
```

1. A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
2. A proxy URL to use for creating HTTPS connections outside the cluster.
3. A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use * to bypass the proxy for all destinations.
4. If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace that contains one or more additional CA certificates that are required for proxying HTTPS connections. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges these contents with the Red Hat Enterprise Linux CoreOS (RHCOS) trust bundle, and this config map is referenced in the **trustedCA** field of the **Proxy** object. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.

NOTE

The installation program does not support the proxy **readinessEndpoints** field.

NOTE

If the installer times out, restart and then complete the deployment by using the **wait-for** command of the installer. For example:

```
$ ./openshift-install wait-for install-complete --log-level debug
```

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.

NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

9.5.7. Manually creating IAM for IBM Cloud VPC

Installing the cluster requires that the Cloud Credential Operator (CCO) operate in manual mode. While the installation program configures the CCO for manual mode, you must specify the identity and access management secrets for you cloud provider.

You can use the Cloud Credential Operator (CCO) utility (**ccoctl**) to create the required IBM Cloud VPC resources.

Prerequisites

- You have configured the **ccoctl** binary.
- You have an existing **install-config.yaml** file.

Procedure

1. Edit the **install-config.yaml** configuration file so that it contains the **credentialsMode** parameter set to **Manual**.

   Example install-config.yaml configuration file

   ```
   apiVersion: v1
   baseDomain: cluster1.example.com
   credentialsMode: Manual 1
   compute:
   - architecture: amd64
     hyperthreading: Enabled
   ...
   ```

   1 This line is added to set the **credentialsMode** parameter to **Manual**.

2. To generate the manifests, run the following command from the directory that contains the installation program:

   ```
   $ openshift-install create manifests --dir <installation_directory>
   ```

3. From the directory that contains the installation program, obtain the OpenShift Container Platform release image that your **openshift-install** binary is built to use:

   ```
   $ RELEASE_IMAGE=$(./openshift-install version | awk '/release image/ {print $3}')
   ```

4. Extract the **CredentialsRequest** objects from the OpenShift Container Platform release image:

   ```
   $ oc adm release extract --cloud=ibmcloud --credentials-requests $RELEASE_IMAGE \
     --to=<path_to_credential_requests_directory> 1
   ```

   1 The directory where the credential requests will be stored.

   This command creates a YAML file for each **CredentialsRequest** object.

   Sample CredentialsRequest object

   ```
   apiVersion: cloudcredential.openshift.io/v1
   kind: CredentialsRequest
   metadata:
     labels:
       controller-tools.k8s.io: "1.0"
     name: openshift-image-registry-ibmcos
     namespace: openshift-cloud-credential-operator
   spec:
   ```

```
    secretRef:
      name: installer-cloud-credentials
      namespace: openshift-image-registry
    providerSpec:
      apiVersion: cloudcredential.openshift.io/v1
      kind: IBMCloudProviderSpec
      policies:
      - attributes:
        - name: serviceName
          value: cloud-object-storage
        roles:
        - crn:v1:bluemix:public:iam::::role:Viewer
        - crn:v1:bluemix:public:iam::::role:Operator
        - crn:v1:bluemix:public:iam::::role:Editor
        - crn:v1:bluemix:public:iam::::serviceRole:Reader
        - crn:v1:bluemix:public:iam::::serviceRole:Writer
      - attributes:
        - name: resourceType
          value: resource-group
        roles:
        - crn:v1:bluemix:public:iam::::role:Viewer
```

5. Create the service ID for each credential request, assign the policies defined, create an API key in IBM Cloud VPC, and generate the secret:

```
$ ccoctl ibmcloud create-service-id \
  --credentials-requests-dir <path_to_store_credential_request_templates> \ 1
  --name <cluster_name> \ 2
  --output-dir <installation_directory> \
  --resource-group-name <resource_group_name> 3
```

1. The directory where the credential requests are stored.
2. The name of the OpenShift Container Platform cluster.
3. Optional: The name of the resource group used for scoping the access policies.

NOTE

If your cluster uses Technology Preview features that are enabled by the **TechPreviewNoUpgrade** feature set, you must include the **--enable-tech-preview** parameter.

If an incorrect resource group name is provided, the installation fails during the bootstrap phase. To find the correct resource group name, run the following command:

```
$ grep resourceGroupName <installation_directory>/manifests/cluster-infrastructure-02-config.yml
```

Verification

- Ensure that the appropriate secrets were generated in your cluster's **manifests** directory.

9.5.8. Network configuration phases

There are two phases prior to OpenShift Container Platform installation where you can customize the network configuration.

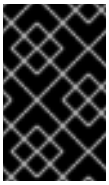
Phase 1

You can customize the following network-related fields in the **install-config.yaml** file before you create the manifest files:

- **networking.networkType**
- **networking.clusterNetwork**
- **networking.serviceNetwork**
- **networking.machineNetwork**
  For more information on these fields, refer to *Installation configuration parameters*.

NOTE

Set the **networking.machineNetwork** to match the CIDR that the preferred NIC resides in.



IMPORTANT

The CIDR range **172.17.0.0/16** is reserved by libVirt. You cannot use this range or any range that overlaps with this range for any networks in your cluster.

Phase 2

After creating the manifest files by running **openshift-install create manifests**, you can define a customized Cluster Network Operator manifest with only the fields you want to modify. You can use the manifest to specify advanced network configuration.

You cannot override the values specified in phase 1 in the **install-config.yaml** file during phase 2. However, you can further customize the cluster network provider during phase 2.

9.5.9. Specifying advanced network configuration

You can use advanced network configuration for your cluster network provider to integrate your cluster into your existing network environment. You can specify advanced network configuration only before you install the cluster.

IMPORTANT

Customizing your network configuration by modifying the OpenShift Container Platform manifest files created by the installation program is not supported. Applying a manifest file that you create, as in the following procedure, is supported.

Prerequisites

- You have created the **install-config.yaml** file and completed any modifications to it.

Procedure

1. Change to the directory that contains the installation program and create the manifests:

```
$ ./openshift-install create manifests --dir <installation_directory> 1
```

1 **<installation_directory>** specifies the name of the directory that contains the **install-config.yaml** file for your cluster.

2. Create a stub manifest file for the advanced network configuration that is named **cluster-network-03-config.yml** in the **<installation_directory>/manifests/** directory:

```
apiVersion: operator.openshift.io/v1
kind: Network
metadata:
  name: cluster
spec:
```

3. Specify the advanced network configuration for your cluster in the **cluster-network-03-config.yml** file, such as in the following example:

Specify a different VXLAN port for the OpenShift SDN network provider

```
apiVersion: operator.openshift.io/v1
kind: Network
metadata:
  name: cluster
spec:
  defaultNetwork:
    openshiftSDNConfig:
      vxlanPort: 4800
```

4. Optional: Back up the **manifests/cluster-network-03-config.yml** file. The installation program consumes the **manifests/** directory when you create the Ignition config files.

9.5.10. Cluster Network Operator configuration

The configuration for the cluster network is specified as part of the Cluster Network Operator (CNO) configuration and stored in a custom resource (CR) object that is named **cluster**. The CR specifies the fields for the **Network** API in the **operator.openshift.io** API group.

The CNO configuration inherits the following fields during cluster installation from the **Network** API in the **Network.config.openshift.io** API group and these fields cannot be changed:

clusterNetwork

IP address pools from which pod IP addresses are allocated.

serviceNetwork

IP address pool for services.

defaultNetwork.type

Cluster network provider, such as OpenShift SDN or OVN-Kubernetes.

You can specify the cluster network provider configuration for your cluster by setting the fields for the **defaultNetwork** object in the CNO object named **cluster**.

9.5.10.1. Cluster Network Operator configuration object

The fields for the Cluster Network Operator (CNO) are described in the following table:

Table 9.11. Cluster Network Operator configuration object

Field	Type	Description
metadata.name	**string**	The name of the CNO object. This name is always **cluster**.
spec.clusterNetwork	**array**	A list specifying the blocks of IP addresses from which pod IP addresses are allocated and the subnet prefix length assigned to each individual node in the cluster. For example: `spec:` `  clusterNetwork:` `  - cidr: 10.128.0.0/19` `  hostPrefix: 23` `  - cidr: 10.128.32.0/19` `  hostPrefix: 23` You can customize this field only in the **install-config.yaml** file before you create the manifests. The value is read-only in the manifest file.
spec.serviceNetwork	**array**	A block of IP addresses for services. The OpenShift SDN and OVN-Kubernetes Container Network Interface (CNI) network providers support only a single IP address block for the service network. For example: `spec:` `  serviceNetwork:` `  - 172.30.0.0/14` You can customize this field only in the **install-config.yaml** file before you create the manifests. The value is read-only in the manifest file.
spec.defaultNetwork	**object**	Configures the Container Network Interface (CNI) cluster network provider for the cluster network.
spec.kubeProxyConfig	**object**	The fields for this object specify the kube-proxy configuration. If you are using the OVN-Kubernetes cluster network provider, the kube-proxy configuration has no effect.

defaultNetwork object configuration

The values for the **defaultNetwork** object are defined in the following table:

Table 9.12. defaultNetwork object

Field	Type	Description
type	**string**	Either **OpenShiftSDN** or **OVNKubernetes**. The cluster network provider is selected during installation. This value cannot be changed after cluster installation.  **NOTE** OpenShift Container Platform uses the OpenShift SDN Container Network Interface (CNI) cluster network provider by default.
openshiftSDNConfig	**object**	This object is only valid for the OpenShift SDN cluster network provider.
ovnKubernetesConfig	**object**	This object is only valid for the OVN-Kubernetes cluster network provider.

Configuration for the OpenShift SDN CNI cluster network provider
The following table describes the configuration fields for the OpenShift SDN Container Network Interface (CNI) cluster network provider.

Table 9.13. **openshiftSDNConfig** object

Field	Type	Description
mode	**string**	Configures the network isolation mode for OpenShift SDN. The default value is **NetworkPolicy**. The values **Multitenant** and **Subnet** are available for backwards compatibility with OpenShift Container Platform 3.x but are not recommended. This value cannot be changed after cluster installation.

Field	Type	Description
mtu	**integer**	The maximum transmission unit (MTU) for the VXLAN overlay network. This is detected automatically based on the MTU of the primary network interface. You do not normally need to override the detected MTU. If the auto-detected value is not what you expect it to be, confirm that the MTU on the primary network interface on your nodes is correct. You cannot use this option to change the MTU value of the primary network interface on the nodes. If your cluster requires different MTU values for different nodes, you must set this value to **50** less than the lowest MTU value in your cluster. For example, if some nodes in your cluster have an MTU of **9001**, and some have an MTU of**1500**, you must set this value to **1450**. This value cannot be changed after cluster installation.
vxlanPort	**integer**	The port to use for all VXLAN packets. The default value is **4789**. This value cannot be changed after cluster installation. If you are running in a virtualized environment with existing nodes that are part of another VXLAN network, then you might be required to change this. For example, when running an OpenShift SDN overlay on top of VMware NSX-T, you must select an alternate port for the VXLAN, because both SDNs use the same default VXLAN port number. On Amazon Web Services (AWS), you can select an alternate port for the VXLAN between port **9000** and port **9999**.

Example OpenShift SDN configuration

```
defaultNetwork:
  type: OpenShiftSDN
  openshiftSDNConfig:
    mode: NetworkPolicy
    mtu: 1450
    vxlanPort: 4789
```

Configuration for the OVN-Kubernetes CNI cluster network provider

The following table describes the configuration fields for the OVN-Kubernetes CNI cluster network provider.

Table 9.14. ovnKubernetesConfig object

Field	Type	Description

Field	Type	Description
mtu	**integer**	The maximum transmission unit (MTU) for the Geneve (Generic Network Virtualization Encapsulation) overlay network. This is detected automatically based on the MTU of the primary network interface. You do not normally need to override the detected MTU. If the auto-detected value is not what you expect it to be, confirm that the MTU on the primary network interface on your nodes is correct. You cannot use this option to change the MTU value of the primary network interface on the nodes. If your cluster requires different MTU values for different nodes, you must set this value to **100** less than the lowest MTU value in your cluster. For example, if some nodes in your cluster have an MTU of **9001**, and some have an MTU of**1500**, you must set this value to **1400**.
genevePort	**integer**	The port to use for all Geneve packets. The default value is **6081**. This value cannot be changed after cluster installation.
policyAuditConfig	**object**	Specify a configuration object for customizing network policy audit logging. If unset, the defaults audit log settings are used.
gatewayConfig	**object**	Optional: Specify a configuration object for customizing how egress traffic is sent to the node gateway.  NOTE While migrating egress traffic, you can expect some disruption to workloads and service traffic until the Cluster Network Operator (CNO) successfully rolls out the changes.

NOTE

IPsec for the OVN-Kubernetes network provider is not supported when installing a cluster on IBM Cloud.

Table 9.15. **policyAuditConfig** object

Field	Type	Description
rateLimit	integer	The maximum number of messages to generate every second per node. The default value is **20** messages per second.
maxFileSize	integer	The maximum size for the audit log in bytes. The default value is **50000000** or 50 MB.

Field	Type	Description
destination	string	One of the following additional audit log targets: **libc** The libc **syslog()** function of the journald process on the host. **udp:<host>:<port>** A syslog server. Replace **<host>:<port>** with the host and port of the syslog server. **unix:<file>** A Unix Domain Socket file specified by **<file>**. **null** Do not send the audit logs to any additional target.
syslogFacility	string	The syslog facility, such as **kern**, as defined by RFC5424. The default value is **local0**.

Table 9.16. **gatewayConfig** object

Field	Type	Description
routingViaHost	**boolean**	Set this field to **true** to send egress traffic from pods to the host networking stack. For highly-specialized installations and applications that rely on manually configured routes in the kernel routing table, you might want to route egress traffic to the host networking stack. By default, egress traffic is processed in OVN to exit the cluster and is not affected by specialized routes in the kernel routing table. The default value is **false**. This field has an interaction with the Open vSwitch hardware offloading feature. If you set this field to **true**, you do not receive the performance benefits of the offloading because egress traffic is processed by the host networking stack.

Example OVN-Kubernetes configuration with IPSec enabled

```
defaultNetwork:
  type: OVNKubernetes
  ovnKubernetesConfig:
    mtu: 1400
    genevePort: 6081
```

kubeProxyConfig object configuration

The values for the **kubeProxyConfig** object are defined in the following table:

Table 9.17. **kubeProxyConfig** object

Field	Type	Description
iptablesSyncPeriod	**string**	The refresh period for **iptables** rules. The default value is **30s**. Valid suffixes include **s**, **m**, and **h** and are described in the Go **time** package documentation. **NOTE** Because of performance improvements introduced in OpenShift Container Platform 4.3 and greater, adjusting the **iptablesSyncPeriod** parameter is no longer necessary.
proxyArguments.iptables-min-sync-period	**array**	The minimum duration before refreshing **iptables** rules. This field ensures that the refresh does not happen too frequently. Valid suffixes include **s**, **m**, and **h** and are described in the Go **time** package. The default value is: `kubeProxyConfig:` `  proxyArguments:` `  iptables-min-sync-period:` `  - 0s`

9.5.11. Deploying the cluster

You can install OpenShift Container Platform on a compatible cloud platform.

IMPORTANT

You can run the **create cluster** command of the installation program only once, during initial installation.

Prerequisites

- Configure an account with the cloud platform that hosts your cluster.
- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.

Procedure

- Change to the directory that contains the installation program and initialize the cluster deployment:

```
$ ./openshift-install create cluster --dir <installation_directory> \ 1
    --log-level=info 2
```

1. For **<installation_directory>**, specify the location of your customized **./install-config.yaml** file.
2. To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

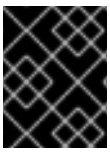
NOTE

If the cloud provider account that you configured on your host does not have sufficient permissions to deploy the cluster, the installation process stops, and the missing permissions are displayed.

Verification

When the cluster deployment completes successfully:

- The terminal displays directions for accessing your cluster, including a link to the web console and credentials for the **kubeadmin** user.
- Credential information also outputs to **<installation_directory>/.openshift_install.log**.

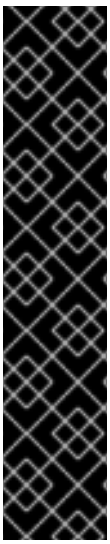


IMPORTANT

Do not delete the installation program or the files that the installation program creates. Both are required to delete the cluster.

Example output

```
...
INFO Install complete!
INFO To access the cluster as the system:admin user when using 'oc', run 'export
KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
INFO Access the OpenShift web-console here: https://console-openshift-
console.apps.mycluster.example.com
INFO Login to the console with user: "kubeadmin", and password: "password"
INFO Time elapsed: 36m22s
```



IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

9.5.12. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.

IMPORTANT

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.11. Download and install the new version of **oc**.

Installing the OpenShift CLI on Linux

You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the architecture in the **Product Variant** drop-down menu.
3. Select the appropriate version in the **Version** drop-down menu.
4. Click **Download Now** next to the **OpenShift v4.11 Linux Client** entry and save the file.
5. Unpack the archive:

```
$ tar xvf <file>
```

6. Place the **oc** binary in a directory that is on your **PATH**.
   To check your **PATH**, execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.
   To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

Verification

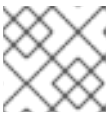
- After you install the OpenShift CLI, it is available using the **oc** command:

```
C:\> oc <command>
```

Installing the OpenShift CLI on macOS
You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 macOS Client** entry and save the file.



NOTE

For macOS arm64, choose the **OpenShift v4.11 macOS arm64 Client** entry.

4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your PATH.
   To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

9.5.13. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

Example output

```
system:admin
```

Additional resources

- Accessing the web console

9.5.14. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.11, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to OpenShift Cluster Manager Hybrid Cloud Console.

After you confirm that your OpenShift Cluster Manager Hybrid Cloud Console inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, use subscription watch to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

Additional resources

- About remote health monitoring

9.5.15. Next steps

- Customize your cluster.
- If necessary, you can opt out of remote health reporting .

9.6. UNINSTALLING A CLUSTER ON IBM CLOUD VPC

You can remove a cluster that you deployed to IBM Cloud VPC.

9.6.1. Removing a cluster that uses installer-provisioned infrastructure

You can remove a cluster that uses installer-provisioned infrastructure from your cloud.

NOTE

After uninstallation, check your cloud provider for any resources not removed properly, especially with User Provisioned Infrastructure (UPI) clusters. There might be resources that the installer did not create or that the installer is unable to access.

Prerequisites

- You have a copy of the installation program that you used to deploy the cluster.
- You have the files that the installation program generated when you created your cluster.
- You have configured the **ccoctl** binary.
- You have installed the IBM Cloud CLI and installed or updated the VPC infrastructure service plugin. For more information see "Prerequisites" in the IBM Cloud VPC CLI documentation.

Procedure

1. If the following conditions are met, this step is required:
   - The installer created a resource group as part of the installation process.
   - You or one of your applications created persistent volume claims (PVCs) after the cluster was deployed.

   In which case, the PVCs are not removed when uninstalling the cluster, which might prevent the resource group from being successfully removed. To prevent a failure:

   a. Log in to the IBM Cloud using the CLI.

   b. To list the PVCs, run the following command:

   ```
   $ ibmcloud is volumes --resource-group-name <infrastructure_id>
   ```

   For more information about listing volumes, see the IBM Cloud VPC CLI documentation.

   c. To delete the PVCs, run the following command:

   ```
   $ ibmcloud is volume-delete --force <volume_id>
   ```

   For more information about deleting volumes, see the IBM Cloud VPC CLI documentation.

2. Export the IBM Cloud API key that was created as part of the installation process.

   ```
   $ export IC_API_KEY=<api_key>
   ```

   NOTE

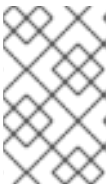
   You must set the variable name exactly as specified. The installation program expects the variable name to be present to remove the service IDs that were created when the cluster was installed.

3. On the computer that you used to install the cluster, go to the directory that contains the installation program, and run the following command:

```
$ ./openshift-install destroy cluster \
--dir <installation_directory> --log-level info 1 2
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2 To view different details, specify **warn**, **debug**, or **error** instead of **info**.



NOTE

You must specify the directory that contains the cluster definition files for your cluster. The installation program requires the **metadata.json** file in this directory to delete the cluster.

4. Remove the manual CCO credentials that were created for the cluster:

```
$ ccoctl ibmcloud delete-service-id \
    --credentials-requests-dir <path_to_credential_requests_directory> \
    --name <cluster_name>
```

NOTE

If your cluster uses Technology Preview features that are enabled by the **TechPreviewNoUpgrade** feature set, you must include the **--enable-tech-preview** parameter.

5. Optional: Delete the **<installation_directory>** directory and the OpenShift Container Platform installation program.

CHAPTER 10. INSTALLING ON NUTANIX

10.1. PREPARING TO INSTALL ON NUTANIX

Before you install an OpenShift Container Platform cluster, be sure that your Nutanix environment meets the following requirements.

10.1.1. Nutanix version requirements

You must install the OpenShift Container Platform cluster to a Nutanix environment that meets the following requirements.

Table 10.1. Version requirements for Nutanix virtual environments

Component	Required version
Nutanix AOS	5.20.4+ or 6.1.1+
Prism Central	2022.4+

10.1.2. Environment requirements

Before you install an OpenShift Container Platform cluster, review the following Nutanix AOS environment requirements.

10.1.2.1. Required account privileges

The installation program requires access to a Nutanix account with the necessary permissions to deploy the cluster and to maintain the daily operation of it. The following options are available to you:

- You can use a local Prism Central user account with administrative privileges. Using a local account is the quickest way to grant access to an account with the required permissions.
- If your organization's security policies require that you use a more restrictive set of permissions, use the permissions that are listed in the following table to create a custom Cloud Native role in Prism Central. You can then assign the role to a user account that is a member of a Prism Central authentication directory. When assigning entities to the role, ensure that the user can access only the Prism Element and subnet that are required to deploy the virtual machines. For more information, see the Nutanix documentation about creating a Custom Cloud Native role and assigning a role.

Example 10.1. Required permissions for creating a Custom Cloud Native role

Nutanix Object	Required permissions in Nutanix API	Description

Nutanix Object	Required permissions in Nutanix API	Description
Categories	**Create_Category_Mapping** **Create_Or_Update_Name_Category** **Create_Or_Update_Value_Category** **Delete_Category_Mapping** **Delete_Name_Category** **Delete_Value_Category** **View_Category_Mapping** **View_Name_Category** **View_Value_Category**	Create, read, and delete categories that are assigned to the OpenShift Container Platform machines.
Images	**Create_Image** **Delete_Image** **View_Image**	Create, read, and delete the operating system images used for the OpenShift Container Platform machines.
Virtual Machines	**Create_Virtual_Machine** **Delete_Virtual_Machine** **View_Virtual_Machine**	Create, read, and delete the OpenShift Container Platform machines.
Clusters	**View_Cluster**	View the Prism Element clusters that host the OpenShift Container Platform machines.
Subnets	**View_Subnet**	View the subnets that host the OpenShift Container Platform machines.

10.1.2.2. Cluster limits

Available resources vary between clusters. The number of possible clusters within a Nutanix environment is limited primarily by available storage space and any limitations associated with the resources that the cluster creates, and resources that you require to deploy the cluster, such a IP addresses and networks.

10.1.2.3. Cluster resources

A minimum of 800 GB of storage is required to use a standard cluster.

When you deploy a OpenShift Container Platform cluster that uses installer-provisioned infrastructure, the installation program must be able to create several resources in your Nutanix instance. Although these resources use 856 GB of storage, the bootstrap node is destroyed as part of the installation process.

A standard OpenShift Container Platform installation creates the following resources:

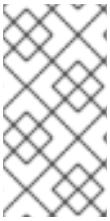
- 1 label

- Virtual machines:
  - 1 disk image
  - 1 temporary bootstrap node
  - 3 control plane nodes
  - 3 compute machines

10.1.2.4. Networking requirements

You must use AHV IP Address Management (IPAM) for the network and ensure that it is configured to provide persistent IP addresses to the cluster machines. Additionally, create the following networking resources before you install the OpenShift Container Platform cluster:

- IP addresses
- DNS records



NOTE

It is recommended that each OpenShift Container Platform node in the cluster have access to a Network Time Protocol (NTP) server that is discoverable via DHCP. Installation is possible without an NTP server. However, an NTP server prevents errors typically associated with asynchronous server clocks.

10.1.2.4.1. Required IP Addresses

An installer-provisioned installation requires two static virtual IP (VIP) addresses:

- A VIP address for the API is required. This address is used to access the cluster API.
- A VIP address for ingress is required. This address is used for cluster ingress traffic.

You specify these IP addresses when you install the OpenShift Container Platform cluster.

10.1.2.4.2. DNS records

You must create DNS records for two static IP addresses in the appropriate DNS server for the Nutanix instance that hosts your OpenShift Container Platform cluster. In each record, **<cluster_name>** is the cluster name and **<base_domain>** is the cluster base domain that you specify when you install the cluster.

A complete DNS record takes the form: **<component>.<cluster_name>.<base_domain>.**.

Table 10.2. Required DNS records

Component	Record	Description

Component	Record	Description
API VIP	**api.<cluster_name>.<base_domain>.**	This DNS A/AAAA or CNAME record must point to the load balancer for the control plane machines. This record must be resolvable by both clients external to the cluster and from all the nodes within the cluster.
Ingress VIP	***.apps.<cluster_name>.<base_domain>.**	A wildcard DNS A/AAAA or CNAME record that points to the load balancer that targets the machines that run the Ingress router pods, which are the worker nodes by default. This record must be resolvable by both clients external to the cluster and from all the nodes within the cluster.

10.1.3. Configuring the Cloud Credential Operator utility

The Cloud Credential Operator (CCO) manages cloud provider credentials as Kubernetes custom resource definitions (CRDs). To install a cluster on Nutanix, you must set the CCO to **manual** mode as part of the installation process.

To create and manage cloud credentials from outside of the cluster when the Cloud Credential Operator (CCO) is operating in manual mode, extract and prepare the CCO utility (**ccoctl**) binary.

NOTE

The **ccoctl** utility is a Linux binary that must run in a Linux environment.

Prerequisites

- You have access to an OpenShift Container Platform account with cluster administrator access.
- You have installed the OpenShift CLI (**oc**).

Procedure

1. Obtain the OpenShift Container Platform release image by running the following command:

```
$ RELEASE_IMAGE=$(./openshift-install version | awk '/release image/ {print $3}')
```

2. Obtain the CCO container image from the OpenShift Container Platform release image by running the following command:

```
$ CCO_IMAGE=$(oc adm release info --image-for='cloud-credential-operator'
$RELEASE_IMAGE -a ~/.pull-secret)
```

NOTE

Ensure that the architecture of the **$RELEASE_IMAGE** matches the architecture of the environment in which you will use the **ccoctl** tool.

3. Extract the **ccoctl** binary from the CCO container image within the OpenShift Container Platform release image by running the following command:

```
$ oc image extract $CCO_IMAGE --file="/usr/bin/ccoctl" -a ~/.pull-secret
```

4. Change the permissions to make **ccoctl** executable by running the following command:

```
$ chmod 775 ccoctl
```

Verification

- To verify that **ccoctl** is ready to use, display the help file by running the following command:

```
$ ccoctl --help
```

Output of ccoctl --help

```
OpenShift credentials provisioning tool

Usage:
  ccoctl [command]

Available Commands:
  alibabacloud Manage credentials objects for alibaba cloud
  aws          Manage credentials objects for AWS cloud
  gcp          Manage credentials objects for Google cloud
  help         Help about any command
  ibmcloud     Manage credentials objects for IBM Cloud
  nutanix      Manage credentials objects for Nutanix

Flags:
  -h, --help   help for ccoctl

Use "ccoctl [command] --help" for more information about a command.
```

Additional resources

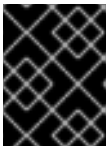
- Preparing to update a cluster with manually maintained credentials

10.2. INSTALLING A CLUSTER ON NUTANIX

In OpenShift Container Platform version 4.11, you can install a cluster on your Nutanix instance that uses installer-provisioned infrastructure.

10.2.1. Prerequisites

- You have reviewed details about the OpenShift Container Platform installation and update processes.
- The installation program requires access to port 9440 on Prism Central and Prism Element. You verified that port 9440 is accessible.
- If you use a firewall, you have met these prerequisites:
  - You confirmed that port 9440 is accessible. Control plane nodes must be able to reach Prism Central and Prism Element on port 9440 for the installation to succeed.
  - You configured the firewall to grant access to the sites that OpenShift Container Platform requires. This includes the use of Telemetry.
- If your Nutanix environment is using the default self-signed SSL certificate, replace it with a certificate that is signed by a CA. The installation program requires a valid CA-signed certificate to access to the Prism Central API. For more information about replacing the self-signed certificate, see the Nutanix AOS Security Guide .
  If your Nutanix environment uses an internal CA to issue certificates, you must configure a cluster-wide proxy as part of the installation process. For more information, see Configuring a custom PKI.



IMPORTANT

Use 2048-bit certificates. The installation fails if you use 4096-bit certificates with Prism Central 2022.x.

10.2.2. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.11, you require access to the internet to install your cluster.

You must have internet access to:

- Access OpenShift Cluster Manager Hybrid Cloud Console to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access Quay.io to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.

IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

10.2.3. Internet access for Prism Central

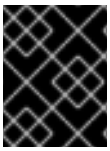
Prism Central requires internet access to obtain the Red Hat Enterprise Linux CoreOS (RHCOS) image that is required to install the cluster. The RHCOS image for Nutanix is available at **rhcos.mirror.openshift.com**.

10.2.4. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the ~/**.ssh/authorized_keys** list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The **./openshift-install gather** command also requires the SSH public key to be in place on the cluster nodes.



IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.

NOTE

You must use a local key, not one that you configured with platform-specific approaches such as AWS key pairs.

Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N '' -f <path>/<file_name> 1
```

1 Specify the path and file name, such as ~/**.ssh/id_ed25519**, of the new SSH key. If you have an existing key pair, ensure your public key is in the your ~/**.ssh** directory.

NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS validated or Modules In Process cryptographic libraries on the **x86_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

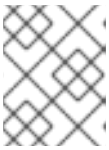
2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the ~/**.ssh/id_ed25519.pub** public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the **./openshift-install gather** command.



NOTE

On some distributions, default SSH private key identities such as **~/.ssh/id_rsa** and **~/.ssh/id_dsa** are managed automatically.

a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

Example output

```
Agent pid 31874
```

NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

1 Specify the path and file name for your SSH private key, such as **~/.ssh/id_ed25519**

Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

10.2.5. Obtaining the installation program

Before you install OpenShift Container Platform, download the installation file on a local computer.

Prerequisites

- You have a computer that runs Linux or macOS, with 500 MB of local disk space.

Procedure

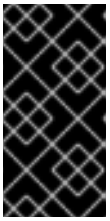
1. Access the Infrastructure Provider page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.

2. Select your infrastructure provider.

3. Navigate to the page for your installation type, download the installation program that corresponds with your host operating system and architecture, and place the file in the directory where you will store the installation configuration files.

IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.



IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation pull secret from the Red Hat OpenShift Cluster Manager . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

10.2.6. Adding Nutanix root CA certificates to your system trust

Because the installation program requires access to the Prism Central API, you must add your Nutanix trusted root CA certificates to your system trust before you install an OpenShift Container Platform cluster.

Procedure

1. From the Prism Central web console, download the Nutanix root CA certificates.

2. Extract the compressed file that contains the Nutanix root CA certificates.

3. Add the files for your operating system to the system trust. For example, on a Fedora operating system, run the following command:

```
# cp certs/lin/* /etc/pki/ca-trust/source/anchors
```

4. Update your system trust. For example, on a Fedora operating system, run the following command:

```
# update-ca-trust extract
```

–

10.2.7. Creating the installation configuration file

You can customize the OpenShift Container Platform cluster you install on Nutanix.

Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.
- Verify that you have met the Nutanix networking requirements. For more information, see "Preparing to install on Nutanix".

Procedure

1. Create the **install-config.yaml** file.
   a. Change to the directory that contains the installation program and run the following command:

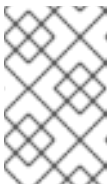
```
$ ./openshift-install create install-config --dir <installation_directory> 1
```

   1 For **<installation_directory>**, specify the directory name to store the files that the installation program creates.

   When specifying the directory:

   - Verify that the directory has the **execute** permission. This permission is required to run Terraform binaries under the installation directory.
   - Use an empty directory. Some installation assets, such as bootstrap X.509 certificates, have short expiration intervals, therefore you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

   b. At the prompts, provide the configuration details for your cloud:
      i. Optional: Select an SSH key to use to access your cluster machines.



NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

      ii. Select **nutanix** as the platform to target.
      iii. Enter the Prism Central domain name or IP address.
      iv. Enter the port that is used to log into Prism Central.
      v. Enter the credentials that are used to log into Prism Central.

The installation program connects to Prism Central.

vi. Select the Prism Element that will manage the OpenShift Container Platform cluster.

vii. Select the network subnet to use.

viii. Enter the virtual IP address that you configured for control plane API access.

ix. Enter the virtual IP address that you configured for cluster ingress.

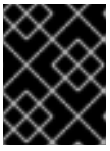
x. Enter the base domain. This base domain must be the same one that you configured in the DNS records.

xi. Enter a descriptive name for your cluster. The cluster name you enter must match the cluster name you specified when configuring the DNS records.

xii. Paste the pull secret from the Red Hat OpenShift Cluster Manager .

2. Optional: Update one or more of the default configuration parameters in the **install.config.yaml** file to customize the installation.
For more information about the parameters, see "Installation configuration parameters".

3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.



IMPORTANT

The **install-config.yaml** file is consumed during the installation process. If you want to reuse the file, you must back it up now.

10.2.7.1. Installation configuration parameters

Before you deploy an OpenShift Container Platform cluster, you provide parameter values to describe your account on the cloud platform that hosts your cluster and optionally customize your cluster's platform. When you create the **install-config.yaml** installation configuration file, you provide values for the required parameters through the command line. If you customize your cluster, you can modify the **install-config.yaml** file to provide more details about the platform.

NOTE

After installation, you cannot modify these parameters in the **install-config.yaml** file.

10.2.7.1.1. Required configuration parameters

Required installation configuration parameters are described in the following table:

Table 10.3. Required parameters

Parameter	Description	Values
apiVersion	The API version for the **install-config.yaml** content. The current version is **v1**. The installer may also support older API versions.	String

Parameter	Description	Values
baseDomain	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the **baseDomain** and **metadata.name** parameter values that uses the **<metadata.name>.<baseDomain>** format.	A fully-qualified domain or subdomain name, such as **example.com**.
metadata	Kubernetes resource **ObjectMeta**, from which only the **name** parameter is consumed.	Object
metadata.name	The name of the cluster. DNS records for the cluster are all subdomains of **{{.metadata.name}}.{{.baseDomain}}**.	String of lowercase letters and hyphens (**-**), such as **dev**.
platform	The configuration for the specific platform upon which to perform the installation: **alibabacloud**, **aws**, **baremetal**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**. For additional information about **platform.<platform>** parameters, consult the table for your specific platform that follows.	Object

Parameter	Description	Values
pullSecret	Get a pull secret from the Red Hat OpenShift Cluster Manager to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	<pre>{ "auths":{ "cloud.openshift.com":{ "auth":"b3Blb=", "email":"you@example.com" }, "quay.io":{ "auth":"b3Blb=", "email":"you@example.com" } } }</pre>

10.2.7.1.2. Network configuration parameters

You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

Only IPv4 addresses are supported.

NOTE

Globalnet is not supported with Red Hat OpenShift Data Foundation disaster recovery solutions. For regional disaster recovery scenarios, ensure that you use a nonoverlapping range of private IP addresses for the cluster and service networks in each cluster.

Table 10.4. Network parameters

Parameter	Description	Values
networking	The configuration for the cluster network.	Object  **NOTE** You cannot modify parameters specified by the **networking** object after installation.

Parameter	Description	Values
networking.networkType	The cluster network provider Container Network Interface (CNI) cluster network provider to install.	Either **OpenShiftSDN** or **OVNKubernetes**. **OpenShiftSDN** is a CNI provider for all-Linux networks. **OVNKubernetes** is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is **OpenShiftSDN**.
networking.clusterNetwork	The IP address blocks for pods. The default value is **10.128.0.0/14** with a host prefix of **/23**. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: `networking:` `  clusterNetwork:` `  - cidr: 10.128.0.0/14` `  hostPrefix: 23`
networking.clusterNetwork.cidr	Required if you use **networking.clusterNetwork**. An IP address block. An IPv4 network.	An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between **0** and **32**.
networking.clusterNetwork.hostPrefix	The subnet prefix length to assign to each individual node. For example, if **hostPrefix** is set to **23** then each node is assigned a **/23** subnet out of the given **cidr**. A **hostPrefix** value of **23** provides 510 (2^(32 - 23) - 2) pod IP addresses.	A subnet prefix. The default value is **23**.
networking.serviceNetwork	The IP address block for services. The default value is **172.30.0.0/16**. The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.	An array with an IP address block in CIDR format. For example: `networking:` `  serviceNetwork:` `  - 172.30.0.0/16`
networking.machineNetwork	The IP address blocks for machines. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: `networking:` `  machineNetwork:` `  - cidr: 10.0.0.0/16`

Parameter	Description	Values
networking.machineNetwork.cidr	Required if you use **networking.machineNetwork**. An IP address block. The default value is **10.0.0.0/16** for all platforms other than libvirt. For libvirt, the default value is **192.168.126.0/24**.	An IP network block in CIDR notation. For example, **10.0.0.0/16**.  **NOTE** Set the **networking.machineNetwork** to match the CIDR that the preferred NIC resides in.

10.2.7.1.3. Optional configuration parameters

Optional installation configuration parameters are described in the following table:

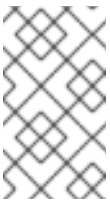
Table 10.5. Optional parameters

Parameter	Description	Values
additionalTrustBundle	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String
capabilities	Controls the installation of optional core cluster components. You can reduce the footprint of your OpenShift Container Platform cluster by disabling optional components.	String array
capabilities.baselineCapabilitySet	Selects an initial set of optional capabilities to enable. Valid values are **None**, **v4.11** and **vCurrent**. **v4.11** enables the **baremetal** Operator, the **marketplace** Operator, and the **openshift-samples** content. **vCurrent** installs the recommended set of capabilities for the current version of OpenShift Container Platform. The default value is **vCurrent**.	String

Parameter	Description	Values
capabilities.additionalEnabledCapabilities	Extends the set of optional capabilities beyond what you specify in **baselineCapabilitySet**. Valid values are **baremetal**, **marketplace** and **openshift-samples**. You may specify multiple capabilities in this parameter.	String array
cgroupsV2	Enables Linux control groups version 2 (cgroups v2) on specific nodes in your cluster. The OpenShift Container Platform process for enabling cgroups v2 disables all cgroup version 1 controllers and hierarchies. The OpenShift Container Platform cgroups version 2 feature is in Developer Preview and is not supported by Red Hat at this time.	**true**
compute	The configuration for the machines that comprise the compute nodes.	Array of **MachinePool** objects.
compute.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** (the default).	String
compute.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  IMPORTANT If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
compute.name	Required if you use **compute**. The name of the machine pool.	**worker**

Parameter	Description	Values
compute.platform	Required if you use **compute**. Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the **controlPlane.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
compute.replicas	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to **2**. The default value is **3**.
controlPlane	The configuration for the machines that comprise the control plane.	Array of **MachinePool** objects.
controlPlane.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** (the default).	String
controlPlane.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  IMPORTANT If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
controlPlane.name	Required if you use **controlPlane**. The name of the machine pool.	**master**

Parameter	Description	Values
controlPlane.platform	Required if you use **controlPlane**. Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the **compute.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
controlPlane.replicas	The number of control plane machines to provision.	The only supported value is **3**, which is the default value.
credentialsMode	The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported.  **NOTE** Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the *Cloud Credential Operator* entry in the *Cluster Operators reference* content.  **NOTE** If your AWS account has service control policies (SCP) enabled, you must configure the **credentialsMode** parameter to **Mint**, **Passthrough** or **Manual**.	**Mint**, **Passthrough**, **Manual** or an empty string (**""**).

Parameter	Description	Values
fips	Enable or disable FIPS mode. The default is **false** (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.  **IMPORTANT** To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.  **NOTE** If you are using Azure File storage, you cannot enable FIPS mode.	**false** or **true**
imageContentSources	Sources and repositories for the release-image content.	Array of objects. Includes a **source** and, optionally, **mirrors**, as described in the following rows of this table.
imageContentSources.source	Required if you use **imageContentSources**. Specify the repository that users refer to, for example, in image pull specifications.	String

Parameter	Description	Values
imageContentSources.mirrors	Specify one or more repositories that may also contain the same images.	Array of strings
publish	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	**Internal** or **External**. The default value is **External**. Setting this field to **Internal** is not supported on non-cloud platforms and IBM Cloud VPC.  IMPORTANT If the value of the field is set to **Internal**, the cluster will become non-functional. For more information, refer to BZ#1953035.
sshKey	The SSH key to authenticate access to your cluster machines.  NOTE For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.	For example, **sshKey: ssh-ed25519 AAAA..**.

10.2.7.1.4. Additional Nutanix configuration parameters

Additional Nutanix configuration parameters are described in the following table:

Table 10.6. Additional Nutanix cluster parameters

Parameter	Description	Values
platform.nutanix.apiVIP	The virtual IP (VIP) address that you configured for control plane API access.	IP address
platform.nutanix.ingressVIP	The virtual IP (VIP) address that you configured for cluster ingress.	IP address

Parameter	Description	Values
platform.nutanix.prismCentral.endpoint.address	The Prism Central domain name or IP address.	String
platform.nutanix.prismCentral.endpoint.port	The port that is used to log into Prism Central.	String
platform.nutanix.prismCentral.password	The password for the Prism Central user name.	String
platform.nutanix.prismCentral.username	The user name that is used to log into Prism Central.	String
platform.nutanix.prismElments.endpoint.address	The Prism Element domain name or IP address. [1]	String
platform.nutanix.prismElments.endpoint.port	The port that is used to log into Prism Element.	String
platform.nutanix.prismElements.uuid	The universally unique identifier (UUID) for Prism Element.	String
platform.nutanix.subnetUUIDs	The UUID of the Prism Element network that contains the virtual IP addresses and DNS records that you configured. [2]	String
platform.nutanix.clusterOSImage	Optional: By default, the installation program downloads and installs the Red Hat Enterprise Linux CoreOS (RHCOS) image. If Prism Central does not have internet access, you can override the default behavior by hosting the RHCOS image on any HTTP server and pointing the installation program to the image.	An HTTP or HTTPS URL, optionally with a SHA-256 checksum. For example, http://example.com/images/rhcos-47.83.202103221318-0-nutanix.x86_64.qcow2

1. The **prismElements** section holds a list of Prism Elements (clusters). A Prism Element encompasses all of the Nutanix resources, for example virtual machines and subnets, that are used to host the OpenShift Container Platform cluster. Only a single Prism Element is supported.

2. Only one subnet per OpenShift Container Platform cluster is supported.

10.2.7.2. Sample customized install-config.yaml file for Nutanix

You can customize the **install-config.yaml** file to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.

IMPORTANT

This sample YAML file is provided for reference only. You must obtain your **install-config.yaml** file by using the installation program and modify it.

```
apiVersion: v1
baseDomain: example.com (1)
compute: (2)
- hyperthreading: Enabled (3)
  name: worker
  replicas: 3
  platform:
    nutanix: (4)
      cpus: 2
      coresPerSocket: 2
      memoryMiB: 8196
      osDisk:
        diskSizeGiB: 120
controlPlane: (5)
  hyperthreading: Enabled (6)
  name: master
  replicas: 3
  platform:
    nutanix: (7)
      cpus: 4
      coresPerSocket: 2
      memoryMiB: 16384
      osDisk:
        diskSizeGiB: 120
metadata:
  creationTimestamp: null
  name: test-cluster (8)
networking:
  clusterNetwork:
  - cidr: 10.128.0.0/14
    hostPrefix: 23
  machineNetwork:
  - cidr: 10.0.0.0/16
  networkType: OpenShiftSDN
  serviceNetwork:
  - 172.30.0.0/16
platform:
  nutanix:
    apiVIP: 10.40.142.7 (9)
    ingressVIP: 10.40.142.8 (10)
    prismCentral:
      endpoint:
        address: your.prismcentral.domainname (11)
        port: 9440 (12)
      password: <password> (13)
```

```
    username: <username> 14
  prismElements:
  - endpoint:
      address: your.prismelement.domainname
      port: 9440
    uuid: 0005b0f1-8f43-a0f2-02b7-3cecef193712
  subnetUUIDs:
  - c7938dc6-7659-453e-a688-e26020c68e43
  clusterOSImage: http://example.com/images/rhcos-47.83.202103221318-0-nutanix.x86_64.qcow2
15
credentialsMode: Manual
publish: External
pullSecret: '{"auths": ...}' 16
fips: false 17
sshKey: ssh-ed25519 AAAA... 18
```

1 8 9 10 11 12 13 14 16 Required. The installation program prompts you for this value.

2 5 The **controlPlane** section is a single mapping, but the compute section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, **-**, and the first line of the **controlPlane** section must not. Although both sections currently define a single machine pool, it is possible that future versions of OpenShift Container Platform will support defining multiple compute pools during installation. Only one control plane pool is used.

3 6 Whether to enable or disable simultaneous multithreading, or **hyperthreading**. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores. You can disable it by setting the parameter value to **Disabled**. If you disable simultaneous multithreading in some cluster machines, you must disable it in all cluster machines.

IMPORTANT

If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.

4 7 Optional: Provide additional configuration for the machine pool parameters for the compute and control plane machines.

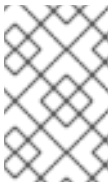
15 Optional: By default, the installation program downloads and installs the Red Hat Enterprise Linux CoreOS (RHCOS) image. If Prism Central does not have internet access, you can override the default behavior by hosting the RHCOS image on any HTTP server and pointing the installation program to the image.

17 Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.

IMPORTANT

The use of FIPS Validated or Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.

18 Optional: You can provide the **sshKey** value that you use to access the machines in your cluster.



NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

10.2.7.3. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.

NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
```

1 A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.

2 A proxy URL to use for creating HTTPS connections outside the cluster.

3 A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use * to bypass the proxy for all destinations.

4 If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace that contains one or more additional CA certificates that are required for proxying HTTPS connections. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges these contents with the Red Hat Enterprise Linux CoreOS (RHCOS) trust bundle, and this config map is referenced in the **trustedCA** field of the **Proxy** object. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.

NOTE

The installation program does not support the proxy **readinessEndpoints** field.

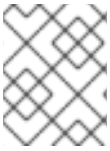
NOTE

If the installer times out, restart and then complete the deployment by using the **wait-for** command of the installer. For example:

```
$ ./openshift-install wait-for install-complete --log-level debug
```

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.

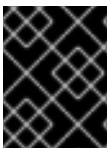


NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

10.2.8. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.



IMPORTANT

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.11. Download and install the new version of **oc**.

Installing the OpenShift CLI on Linux

You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the architecture in the **Product Variant** drop-down menu.
3. Select the appropriate version in the **Version** drop-down menu.
4. Click **Download Now** next to the **OpenShift v4.11 Linux Client** entry and save the file.
5. Unpack the archive:

```
$ tar xvf <file>
```

6. Place the **oc** binary in a directory that is on your **PATH**.
   To check your **PATH**, execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.
   To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

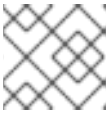
```
C:\> oc <command>
```

Installing the OpenShift CLI on macOS

You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 macOS Client** entry and save the file.



NOTE

For macOS arm64, choose the **OpenShift v4.11 macOS arm64 Client** entry.

4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your PATH.
To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

10.2.9. Configuring IAM for Nutanix

Installing the cluster requires that the Cloud Credential Operator (CCO) operate in manual mode. While the installation program configures the CCO for manual mode, you must specify the identity and access management secrets.

Prerequisites

- You have configured the **ccoctl** binary.
- You have an **install-config.yaml** file.

Procedure

1. Create a YAML file that contains the credentials data in the following format:

Credentials data format

```
credentials:
- type: basic_auth (1)
  data:
    prismCentral: (2)
      username: <username_for_prism_central>
      password: <password_for_prism_central>
    prismElements: (3)
    - name: <name_of_prism_element>
      username: <username_for_prism_element>
      password: <password_for_prism_element>
```

1. Specify the authentication type. Only basic authentication is supported.
2. Specify the Prism Central credentials.
3. Optional: Specify the Prism Element credentials.

2. Extract the list of **CredentialsRequest** custom resources (CRs) from the OpenShift Container Platform release image by running the following command:

```
$ oc adm release extract --credentials-requests --cloud=nutanix \/
--to=<path_to_directory_with_list_of_credentials_requests>/credrequests \ 1
quay.io/<path_to>/ocp-release:<version>
```

1. Specify the path to the directory that contains the files for the component **CredentialsRequests** objects. If the specified directory does not exist, this command creates it.

Sample CredentialsRequest object

```
apiVersion: cloudcredential.openshift.io/v1
kind: CredentialsRequest
metadata:
  annotations:
    include.release.openshift.io/self-managed-high-availability: "true"
  labels:
    controller-tools.k8s.io: "1.0"
  name: openshift-machine-api-nutanix
  namespace: openshift-cloud-credential-operator
spec:
  providerSpec:
    apiVersion: cloudcredential.openshift.io/v1
    kind: NutanixProviderSpec
  secretRef:
    name: nutanix-credentials
    namespace: openshift-machine-api
```

3. Use the **ccoctl** tool to process all of the **CredentialsRequest** objects in the **credrequests** directory by running the following command:

```
$ ccoctl nutanix create-shared-secrets \
--credentials-requests-dir=
<path_to_directory_with_list_of_credentials_requests>/credrequests \ 1
--output-dir=<ccoctl_output_dir> \ 2
--credentials-source-filepath=<path_to_credentials_file> 3
```

1. Specify the path to the directory that contains the files for the component **CredentialsRequests** objects.
2. Specify the directory that contains the files of the component credentials secrets, under the **manifests** directory. By default, the **ccoctl** tool creates objects in the directory in which the commands are run. To create the objects in a different directory, use the **--output-dir** flag.

3 Optional: Specify the directory that contains the credentials data YAML file. By default, **ccoctl** expects this file to be in **<home_directory>/.nutanix/credentials**. To specify a

4. Edit the **install-config.yaml** configuration file so that the **credentialsMode** parameter is set to **Manual**.

Example install-config.yaml configuration file

```
apiVersion: v1
baseDomain: cluster1.example.com
credentialsMode: Manual 1
...
```

1 Add this line to set the **credentialsMode** parameter to **Manual**.

5. Create the installation manifests by running the following command:

```
$ openshift-install create manifests --dir <installation_directory> 1
```

1 Specify the path to the directory that contains the **install-config.yaml** file for your cluster.

6. Copy the generated credential files to the target manifests directory by running the following command:

```
$ cp <ccoctl_output_dir>/manifests/*credentials.yaml ./<installation_directory>/manifests
```

Verification

- Ensure that the appropriate secrets exist in the **manifests** directory.

```
$ ls ./<installation_directory>/manifests
```

Example output

```
total 64
-rw-r----- 1 <user> <user> 2335 Jul  8 12:22 cluster-config.yaml
-rw-r----- 1 <user> <user>  161 Jul  8 12:22 cluster-dns-02-config.yml
-rw-r----- 1 <user> <user>  864 Jul  8 12:22 cluster-infrastructure-02-config.yml
-rw-r----- 1 <user> <user>  191 Jul  8 12:22 cluster-ingress-02-config.yml
-rw-r----- 1 <user> <user> 9607 Jul  8 12:22 cluster-network-01-crd.yml
-rw-r----- 1 <user> <user>  272 Jul  8 12:22 cluster-network-02-config.yml
-rw-r----- 1 <user> <user>  142 Jul  8 12:22 cluster-proxy-01-config.yaml
-rw-r----- 1 <user> <user>  171 Jul  8 12:22 cluster-scheduler-02-config.yml
-rw-r----- 1 <user> <user>  200 Jul  8 12:22 cvo-overrides.yaml
-rw-r----- 1 <user> <user>  118 Jul  8 12:22 kube-cloud-config.yaml
-rw-r----- 1 <user> <user> 1304 Jul  8 12:22 kube-system-configmap-root-ca.yaml
-rw-r----- 1 <user> <user> 4090 Jul  8 12:22 machine-config-server-tls-secret.yaml
-rw-r----- 1 <user> <user> 3961 Jul  8 12:22 openshift-config-secret-pull-secret.yaml
-rw------- 1 <user> <user>  283 Jul  8 12:24 openshift-machine-api-nutanix-credentials-
credentials.yaml
```

10.2.10. Deploying the cluster

You can install OpenShift Container Platform on a compatible cloud platform.

IMPORTANT

You can run the **create cluster** command of the installation program only once, during initial installation.

Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.

Procedure

- Change to the directory that contains the installation program and initialize the cluster deployment:

```
$ ./openshift-install create cluster --dir <installation_directory> \ 1
    --log-level=info 2
```

1 For **<installation_directory>**, specify the location of your customized **./install-config.yaml** file.

2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

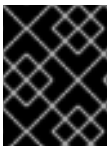
NOTE

If the cloud provider account that you configured on your host does not have sufficient permissions to deploy the cluster, the installation process stops, and the missing permissions are displayed.

Verification

When the cluster deployment completes successfully:

- The terminal displays directions for accessing your cluster, including a link to the web console and credentials for the **kubeadmin** user.
- Credential information also outputs to **<installation_directory>/.openshift_install.log**.



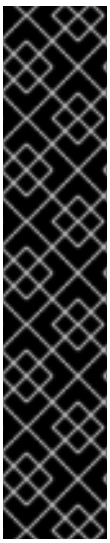
IMPORTANT

Do not delete the installation program or the files that the installation program creates. Both are required to delete the cluster.

Example output

```
...
INFO Install complete!
INFO To access the cluster as the system:admin user when using 'oc', run 'export
KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
```

```
INFO Access the OpenShift web-console here: https://console-openshift-
console.apps.mycluster.example.com
INFO Login to the console with user: "kubeadmin", and password: "password"
INFO Time elapsed: 36m22s
```



IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

10.2.11. Configuring the default storage container

After you install the cluster, you must install the Nutanix CSI Operator and configure the default storage container for the cluster.

For more information, see the Nutanix documentation for installing the CSI Operator and configuring registry storage.

10.2.12. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.11, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to OpenShift Cluster Manager Hybrid Cloud Console.

After you confirm that your OpenShift Cluster Manager Hybrid Cloud Console inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, use subscription watch to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

10.2.13. Additional resources

- About remote health monitoring

10.2.14. Next steps

- Opt out of remote health reporting
- Customize your cluster

10.3. UNINSTALLING A CLUSTER ON NUTANIX

You can remove a cluster that you deployed to Nutanix.

10.3.1. Removing a cluster that uses installer-provisioned infrastructure

You can remove a cluster that uses installer-provisioned infrastructure from your cloud.

NOTE

After uninstallation, check your cloud provider for any resources not removed properly, especially with User Provisioned Infrastructure (UPI) clusters. There might be resources that the installer did not create or that the installer is unable to access.

Prerequisites

- You have a copy of the installation program that you used to deploy the cluster.
- You have the files that the installation program generated when you created your cluster.

Procedure

1. On the computer that you used to install the cluster, go to the directory that contains the installation program, and run the following command:

```
$ ./openshift-install destroy cluster \
--dir <installation_directory> --log-level info 1 2
```

1. For **<installation_directory>**, specify the path to the directory that you stored the installation files in.
2. To view different details, specify **warn**, **debug**, or **error** instead of **info**.

NOTE

You must specify the directory that contains the cluster definition files for your cluster. The installation program requires the **metadata.json** file in this directory to delete the cluster.

2. Optional: Delete the **<installation_directory>** directory and the OpenShift Container Platform installation program.

CHAPTER 11. INSTALLING ON BARE METAL

11.1. PREPARING FOR BARE METAL CLUSTER INSTALLATION

11.1.1. Prerequisites

- You reviewed details about the OpenShift Container Platform installation and update processes.
- You have read the documentation on selecting a cluster installation method and preparing it for users.

11.1.2. Planning a bare metal cluster for OpenShift Virtualization

If you will use OpenShift Virtualization, it is important to be aware of several requirements before you install your bare metal cluster.

- If you want to use live migration features, you must have multiple worker nodes *at the time of cluster installation*. This is because live migration requires the cluster-level high availability (HA) flag to be set to true. The HA flag is set when a cluster is installed and cannot be changed afterwards. If there are fewer than two worker nodes defined when you install your cluster, the HA flag is set to false for the life of the cluster.

  NOTE

  You can install OpenShift Virtualization on a single-node cluster, but single-node OpenShift does not support high availability.

- Live migration requires shared storage. Storage for OpenShift Virtualization must support and use the ReadWriteMany (RWX) access mode.
- If you plan to use Single Root I/O Virtualization (SR-IOV), ensure that your network interface controllers (NICs) are supported by OpenShift Container Platform.

Additional resources

- Preparing your cluster for OpenShift Virtualization
- About Single Root I/O Virtualization (SR-IOV) hardware networks
- Connecting a virtual machine to an SR-IOV network

11.1.3. Choosing a method to install OpenShift Container Platform on bare metal

You can install OpenShift Container Platform on installer-provisioned or user-provisioned infrastructure. The default installation type uses installer-provisioned infrastructure, where the installation program provisions the underlying infrastructure for the cluster. You can also install OpenShift Container Platform on infrastructure that you provision. If you do not use infrastructure that the installation program provisions, you must manage and maintain the cluster resources yourself.

See Installation process for more information about installer-provisioned and user-provisioned installation processes.

11.1.3.1. Installing a cluster on installer-provisioned infrastructure

You can install a cluster on bare metal infrastructure that is provisioned by the OpenShift Container Platform installation program, by using the following method:

- **Installing an installer-provisioned cluster on bare metal**: You can install OpenShift Container Platform on bare metal by using installer provisioning.

11.1.3.2. Installing a cluster on user-provisioned infrastructure

You can install a cluster on bare metal infrastructure that you provision, by using one of the following methods:

- **Installing a user-provisioned cluster on bare metal**: You can install OpenShift Container Platform on bare metal infrastructure that you provision. For a cluster that contains user-provisioned infrastructure, you must deploy all of the required machines.
- **Installing a user-provisioned bare metal cluster with network customizations**: You can install a bare metal cluster on user-provisioned infrastructure with network-customizations. By customizing your network configuration, your cluster can coexist with existing IP address allocations in your environment and integrate with existing MTU and VXLAN configurations. Most of the network customizations must be applied at the installation stage.
- **Installing a user-provisioned bare metal cluster on a restricted network**: You can install a user-provisioned bare metal cluster on a restricted or disconnected network by using a mirror registry. You can also use this installation method to ensure that your clusters only use container images that satisfy your organizational controls on external content.

11.2. INSTALLING A USER-PROVISIONED CLUSTER ON BARE METAL

In OpenShift Container Platform 4.11, you can install a cluster on bare metal infrastructure that you provision.

IMPORTANT

While you might be able to follow this procedure to deploy a cluster on virtualized or cloud environments, you must be aware of additional considerations for non-bare metal platforms. Review the information in the guidelines for deploying OpenShift Container Platform on non-tested platforms before you attempt to install an OpenShift Container Platform cluster in such an environment.

11.2.1. Prerequisites

- You reviewed details about the OpenShift Container Platform installation and update processes.
- You read the documentation on selecting a cluster installation method and preparing it for users.
- If you use a firewall, you configured it to allow the sites that your cluster requires access to.

NOTE

Be sure to also review this site list if you are configuring a proxy.

11.2.2. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.11, you require access to the internet to install your cluster.

You must have internet access to:

- Access OpenShift Cluster Manager Hybrid Cloud Console to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access Quay.io to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.

IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

Additional resources

- See Installing a user-provisioned bare metal cluster on a restricted network for more information about performing a restricted network installation on bare metal infrastructure that you provision.

11.2.3. Requirements for a cluster with user-provisioned infrastructure

For a cluster that contains user-provisioned infrastructure, you must deploy all of the required machines.

This section describes the requirements for deploying OpenShift Container Platform on user-provisioned infrastructure.

11.2.3.1. Required machines for cluster installation

The smallest OpenShift Container Platform clusters require the following hosts:

Table 11.1. Minimum required hosts

Hosts	Description
One temporary bootstrap machine	The cluster requires the bootstrap machine to deploy the OpenShift Container Platform cluster on the three control plane machines. You can remove the bootstrap machine after you install the cluster.
Three control plane machines	The control plane machines run the Kubernetes and OpenShift Container Platform services that form the control plane.

Hosts	Description
At least two compute machines, which are also known as worker machines.	The workloads requested by OpenShift Container Platform users run on the compute machines.

NOTE

As an exception, you can run zero compute machines in a bare metal cluster that consists of three control plane machines only. This provides smaller, more resource efficient clusters for cluster administrators and developers to use for testing, development, and production. Running one compute machine is not supported.

IMPORTANT

To maintain high availability of your cluster, use separate physical hosts for these cluster machines.

The bootstrap and control plane machines must use Red Hat Enterprise Linux CoreOS (RHCOS) as the operating system. However, the compute machines can choose between Red Hat Enterprise Linux CoreOS (RHCOS), Red Hat Enterprise Linux (RHEL) 8.6 and later.

Note that RHCOS is based on Red Hat Enterprise Linux (RHEL) 8 and inherits all of its hardware certifications and requirements. See Red Hat Enterprise Linux technology capabilities and limits .

11.2.3.2. Minimum resource requirements for cluster installation

Each cluster machine must meet the following minimum requirements:

Table 11.2. Minimum resource requirements

Machine	Operating System	CPU [1]	RAM	Storage	IOPS [2]
Bootstrap	RHCOS	4	16 GB	100 GB	300
Control plane	RHCOS	4	16 GB	100 GB	300
Compute	RHCOS, RHEL 8.6 and later [3]	2	8 GB	100 GB	300

1. One CPU is equivalent to one physical core when simultaneous multithreading (SMT), or hyperthreading, is not enabled. When enabled, use the following formula to calculate the corresponding ratio: (threads per core × cores) × sockets = CPUs.

2. OpenShift Container Platform and Kubernetes are sensitive to disk performance, and faster storage is recommended, particularly for etcd on the control plane nodes which require a 10 ms p99 fsync duration. Note that on many cloud platforms, storage size and IOPS scale together, so you might need to over-allocate storage volume to obtain sufficient performance.

3. As with all user-provisioned installations, if you choose to use RHEL compute machines in your

cluster, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks. Use of RHEL 7 compute machines is deprecated and has been removed in OpenShift Container Platform 4.10 and later.

If an instance type for your platform meets the minimum requirements for cluster machines, it is supported to use in OpenShift Container Platform.

Additional resources

- Optimizing storage

11.2.3.3. Certificate signing requests management

Because your cluster has limited access to automatic machine management when you use infrastructure that you provision, you must provide a mechanism for approving cluster certificate signing requests (CSRs) after installation. The **kube-controller-manager** only approves the kubelet client CSRs. The **machine-approver** cannot guarantee the validity of a serving certificate that is requested by using kubelet credentials because it cannot confirm that the correct machine issued the request. You must determine and implement a method of verifying the validity of the kubelet serving certificate requests and approving them.

Additional resources

- See Configuring a three-node cluster for details about deploying three-node clusters in bare metal environments.
- See Approving the certificate signing requests for your machines for more information about approving cluster certificate signing requests after installation.

11.2.3.4. Networking requirements for user-provisioned infrastructure

All the Red Hat Enterprise Linux CoreOS (RHCOS) machines require networking to be configured in **initramfs** during boot to fetch their Ignition config files.

During the initial boot, the machines require an IP address configuration that is set either through a DHCP server or statically by providing the required boot options. After a network connection is established, the machines download their Ignition config files from an HTTP or HTTPS server. The Ignition config files are then used to set the exact state of each machine. The Machine Config Operator completes more changes to the machines, such as the application of new certificates or keys, after installation.

It is recommended to use a DHCP server for long-term management of the cluster machines. Ensure that the DHCP server is configured to provide persistent IP addresses, DNS server information, and hostnames to the cluster machines.

NOTE

If a DHCP service is not available for your user-provisioned infrastructure, you can instead provide the IP networking configuration and the address of the DNS server to the nodes at RHCOS install time. These can be passed as boot arguments if you are installing from an ISO image. See the *Installing RHCOS and starting the OpenShift Container Platform bootstrap process* section for more information about static IP provisioning and advanced networking options.

The Kubernetes API server must be able to resolve the node names of the cluster machines. If the API servers and worker nodes are in different zones, you can configure a default DNS search zone to allow the API server to resolve the node names. Another supported approach is to always refer to hosts by their fully-qualified domain names in both the node objects and all DNS requests.

11.2.3.4.1. Setting the cluster node hostnames through DHCP

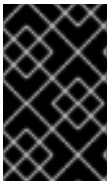
On Red Hat Enterprise Linux CoreOS (RHCOS) machines, the hostname is set through NetworkManager. By default, the machines obtain their hostname through DHCP. If the hostname is not provided by DHCP, set statically through kernel arguments, or another method, it is obtained through a reverse DNS lookup. Reverse DNS lookup occurs after the network has been initialized on a node and can take time to resolve. Other system services can start prior to this and detect the hostname as **localhost** or similar. You can avoid this by using DHCP to provide the hostname for each cluster node.

Additionally, setting the hostnames through DHCP can bypass any manual DNS record name configuration errors in environments that have a DNS split-horizon implementation.

11.2.3.4.2. Network connectivity requirements

You must configure the network connectivity between machines to allow OpenShift Container Platform cluster components to communicate. Each machine must be able to resolve the hostnames of all other machines in the cluster.

This section provides details about the ports that are required.



IMPORTANT

In connected OpenShift Container Platform environments, all nodes are required to have internet access to pull images for platform containers and provide telemetry data to Red Hat.

Table 11.3. Ports used for all-machine to all-machine communications

Protocol	Port	Description
ICMP	N/A	Network reachability tests
TCP	**1936**	Metrics
	9000-**9999**	Host level services, including the node exporter on ports **9100**-**9101** and the Cluster Version Operator on port**9099**.
	10250-**10259**	The default ports that Kubernetes reserves
	10256	openshift-sdn
UDP	**4789**	VXLAN
	6081	Geneve

Protocol	Port	Description
	9000-**9999**	Host level services, including the node exporter on ports **9100**-**9101**.
	500	IPsec IKE packets
	4500	IPsec NAT-T packets
TCP/UDP	**30000**-**32767**	Kubernetes node port
ESP	N/A	IPsec Encapsulating Security Payload (ESP)

Table 11.4. Ports used for all-machine to control plane communications

Protocol	Port	Description
TCP	**6443**	Kubernetes API

Table 11.5. Ports used for control plane machine to control plane machine communications

Protocol	Port	Description
TCP	**2379**-**2380**	etcd server and peer ports

NTP configuration for user-provisioned infrastructure
OpenShift Container Platform clusters are configured to use a public Network Time Protocol (NTP) server by default. If you want to use a local enterprise NTP server, or if your cluster is being deployed in a disconnected network, you can configure the cluster to use a specific time server. For more information, see the documentation for *Configuring chrony time service* .

If a DHCP server provides NTP server information, the chrony time service on the Red Hat Enterprise Linux CoreOS (RHCOS) machines read the information and can sync the clock with the NTP servers.

Additional resources

- Configuring chrony time service

11.2.3.5. User-provisioned DNS requirements

In OpenShift Container Platform deployments, DNS name resolution is required for the following components:

- The Kubernetes API
- The OpenShift Container Platform application wildcard
- The bootstrap, control plane, and compute machines

Reverse DNS resolution is also required for the Kubernetes API, the bootstrap machine, the control plane machines, and the compute machines.

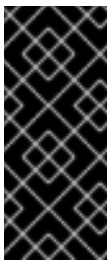
DNS A/AAAA or CNAME records are used for name resolution and PTR records are used for reverse name resolution. The reverse records are important because Red Hat Enterprise Linux CoreOS (RHCOS) uses the reverse records to set the hostnames for all the nodes, unless the hostnames are provided by DHCP. Additionally, the reverse records are used to generate the certificate signing requests (CSR) that OpenShift Container Platform needs to operate.

NOTE

It is recommended to use a DHCP server to provide the hostnames to each cluster node. See the *DHCP recommendations for user-provisioned infrastructure* section for more information.

The following DNS records are required for a user-provisioned OpenShift Container Platform cluster and they must be in place before installation. In each record, **<cluster_name>** is the cluster name and **<base_domain>** is the base domain that you specify in the **install-config.yaml** file. A complete DNS record takes the form: **<component>.<cluster_name>.<base_domain>.**.

Table 11.6. Required DNS records

Component	Record	Description
Kubernetes API	**api.<cluster_name>. <base_domain>.**	A DNS A/AAAA or CNAME record, and a DNS PTR record, to identify the API load balancer. These records must be resolvable by both clients external to the cluster and from all the nodes within the cluster.
	api-int.<cluster_name>. <base_domain>.	A DNS A/AAAA or CNAME record, and a DNS PTR record, to internally identify the API load balancer. These records must be resolvable from all the nodes within the cluster.  IMPORTANT The API server must be able to resolve the worker nodes by the hostnames that are recorded in Kubernetes. If the API server cannot resolve the node names, then proxied API calls can fail, and you cannot retrieve logs from pods.
Routes	***.apps.<cluster_name>. <base_domain>.**	A wildcard DNS A/AAAA or CNAME record that refers to the application ingress load balancer. The application ingress load balancer targets the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default. These records must be resolvable by both clients external to the cluster and from all the nodes within the cluster. For example, **console-openshift-console.apps. <cluster_name>.<base_domain>** is used as a wildcard route to the OpenShift Container Platform console.

Component	Record	Description
Bootstrap machine	**bootstrap.<cluster_name>.<base_domain>.**	A DNS A/AAAA or CNAME record, and a DNS PTR record, to identify the bootstrap machine. These records must be resolvable by the nodes within the cluster.
Control plane machines	**<master><n>.<cluster_name>.<base_domain>.**	DNS A/AAAA or CNAME records and DNS PTR records to identify each machine for the control plane nodes. These records must be resolvable by the nodes within the cluster.
Compute machines	**<worker><n>.<cluster_name>.<base_domain>.**	DNS A/AAAA or CNAME records and DNS PTR records to identify each machine for the worker nodes. These records must be resolvable by the nodes within the cluster.

NOTE

In OpenShift Container Platform 4.4 and later, you do not need to specify etcd host and SRV records in your DNS configuration.

TIP

You can use the **dig** command to verify name and reverse name resolution. See the section on *Validating DNS resolution for user-provisioned infrastructure* for detailed validation steps.

11.2.3.5.1. Example DNS configuration for user-provisioned clusters

This section provides A and PTR record configuration samples that meet the DNS requirements for deploying OpenShift Container Platform on user-provisioned infrastructure. The samples are not meant to provide advice for choosing one DNS solution over another.

In the examples, the cluster name is **ocp4** and the base domain is **example.com**.

Example DNS A record configuration for a user-provisioned cluster

The following example is a BIND zone file that shows sample A records for name resolution in a user-provisioned cluster.

Example 11.1. Sample DNS zone database

```
$TTL 1W
@ IN SOA ns1.example.com. root (
  2019070700 ; serial
  3H  ; refresh (3 hours)
  30M  ; retry (30 minutes)
  2W  ; expiry (2 weeks)
  1W )  ; minimum (1 week)
 IN NS ns1.example.com.
 IN MX 10 smtp.example.com.
;
;
```

```
ns1.example.com.  IN A 192.168.1.5
smtp.example.com.  IN A 192.168.1.5
;
helper.example.com.  IN A 192.168.1.5
helper.ocp4.example.com. IN A 192.168.1.5
;
api.ocp4.example.com.  IN A 192.168.1.5 1
api-int.ocp4.example.com. IN A 192.168.1.5 2
;
*.apps.ocp4.example.com. IN A 192.168.1.5 3
;
bootstrap.ocp4.example.com. IN A 192.168.1.96 4
;
master0.ocp4.example.com. IN A 192.168.1.97 5
master1.ocp4.example.com. IN A 192.168.1.98 6
master2.ocp4.example.com. IN A 192.168.1.99 7
;
worker0.ocp4.example.com. IN A 192.168.1.11 8
worker1.ocp4.example.com. IN A 192.168.1.7 9
;
;EOF
```

1 Provides name resolution for the Kubernetes API. The record refers to the IP address of the API load balancer.

2 Provides name resolution for the Kubernetes API. The record refers to the IP address of the API load balancer and is used for internal cluster communications.

3 Provides name resolution for the wildcard routes. The record refers to the IP address of the application ingress load balancer. The application ingress load balancer targets the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.

NOTE

In the example, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

4 Provides name resolution for the bootstrap machine.

5 6 7 Provides name resolution for the control plane machines.

8 9 Provides name resolution for the compute machines.

Example DNS PTR record configuration for a user-provisioned cluster

The following example BIND zone file shows sample PTR records for reverse name resolution in a user-provisioned cluster.

Example 11.2. Sample DNS zone database for reverse records

```
$TTL 1W
@ IN SOA ns1.example.com. root (
  2019070700 ; serial
  3H  ; refresh (3 hours)
  30M  ; retry (30 minutes)
  2W  ; expiry (2 weeks)
  1W )  ; minimum (1 week)
 IN NS ns1.example.com.
;
5.1.168.192.in-addr.arpa. IN PTR api.ocp4.example.com. 1
5.1.168.192.in-addr.arpa. IN PTR api-int.ocp4.example.com. 2
;
96.1.168.192.in-addr.arpa. IN PTR bootstrap.ocp4.example.com. 3
;
97.1.168.192.in-addr.arpa. IN PTR master0.ocp4.example.com. 4
98.1.168.192.in-addr.arpa. IN PTR master1.ocp4.example.com. 5
99.1.168.192.in-addr.arpa. IN PTR master2.ocp4.example.com. 6
;
11.1.168.192.in-addr.arpa. IN PTR worker0.ocp4.example.com. 7
7.1.168.192.in-addr.arpa. IN PTR worker1.ocp4.example.com. 8
;
;EOF
```

1 Provides reverse DNS resolution for the Kubernetes API. The PTR record refers to the record name of the API load balancer.

2 Provides reverse DNS resolution for the Kubernetes API. The PTR record refers to the record name of the API load balancer and is used for internal cluster communications.

3 Provides reverse DNS resolution for the bootstrap machine.

4 5 6 Provides reverse DNS resolution for the control plane machines.

7 8 Provides reverse DNS resolution for the compute machines.

NOTE

A PTR record is not required for the OpenShift Container Platform application wildcard.

Additional resources

- Validating DNS resolution for user-provisioned infrastructure

11.2.3.6. Load balancing requirements for user-provisioned infrastructure

Before you install OpenShift Container Platform, you must provision the API and application ingress load balancing infrastructure. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

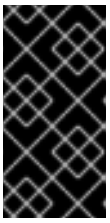
NOTE

If you want to deploy the API and application Ingress load balancers with a Red Hat Enterprise Linux (RHEL) instance, you must purchase the RHEL subscription separately.

The load balancing infrastructure must meet the following requirements:

1. **API load balancer**: Provides a common endpoint for users, both human and machine, to interact with and configure the platform. Configure the following conditions:

   - Layer 4 load balancing only. This can be referred to as Raw TCP, SSL Passthrough, or SSL Bridge mode. If you use SSL Bridge mode, you must enable Server Name Indication (SNI) for the API routes.
   - A stateless load balancing algorithm. The options vary based on the load balancer implementation.



IMPORTANT

Do not configure session persistence for an API load balancer. Configuring session persistence for a Kubernetes API server might cause performance issues from excess application traffic for your OpenShift Container Platform cluster and the Kubernetes API that runs inside the cluster.

Configure the following ports on both the front and back of the load balancers:

Table 11.7. API load balancer

Port	Back-end machines (pool members)	Internal	External	Description
6443	Bootstrap and control plane. You remove the bootstrap machine from the load balancer after the bootstrap machine initializes the cluster control plane. You must configure the **/readyz** endpoint for the API server health check probe.	X	X	Kubernetes API server
22623	Bootstrap and control plane. You remove the bootstrap machine from the load balancer after the bootstrap machine initializes the cluster control plane.	X		Machine config server

NOTE

The load balancer must be configured to take a maximum of 30 seconds from the time the API server turns off the **/readyz** endpoint to the removal of the API server instance from the pool. Within the time frame after **/readyz** returns an error or becomes healthy, the endpoint must have been removed or added. Probing every 5 or 10 seconds, with two successful requests to become healthy and three to become unhealthy, are well-tested values.

2. **Application Ingress load balancer**: Provides an ingress point for application traffic flowing in from outside the cluster. A working configuration for the Ingress router is required for an OpenShift Container Platform cluster.
   Configure the following conditions:

   - Layer 4 load balancing only. This can be referred to as Raw TCP, SSL Passthrough, or SSL Bridge mode. If you use SSL Bridge mode, you must enable Server Name Indication (SNI) for the ingress routes.
   - A connection-based or session-based persistence is recommended, based on the options available and types of applications that will be hosted on the platform.

   TIP

   If the true IP address of the client can be seen by the application Ingress load balancer, enabling source IP-based session persistence can improve performance for applications that use end-to-end TLS encryption.

   Configure the following ports on both the front and back of the load balancers:

   Table 11.8. Application Ingress load balancer

Port	Back-end machines (pool members)	Internal	External	Description
443	The machines that run the Ingress Controller pods, compute, or worker, by default.	X	X	HTTPS traffic
80	The machines that run the Ingress Controller pods, compute, or worker, by default.	X	X	HTTP traffic

NOTE

If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application Ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes.

11.2.3.6.1. Example load balancer configuration for user-provisioned clusters

This section provides an example API and application ingress load balancer configuration that meets the load balancing requirements for user-provisioned clusters. The sample is an **/etc/haproxy/haproxy.cfg** configuration for an HAProxy load balancer. The example is not meant to provide advice for choosing one load balancing solution over another.

In the example, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

NOTE

If you are using HAProxy as a load balancer and SELinux is set to **enforcing**, you must ensure that the HAProxy service can bind to the configured TCP port by running **setsebool -P haproxy_connect_any=1**.

Example 11.3. Sample API and application Ingress load balancer configuration

```
global
  log         127.0.0.1 local2
  pidfile     /var/run/haproxy.pid
  maxconn     4000
  daemon
defaults
  mode                    http
  log                     global
  option                  dontlognull
  option http-server-close
  option                  redispatch
  retries                 3
  timeout http-request    10s
  timeout queue           1m
  timeout connect         10s
  timeout client          1m
  timeout server          1m
  timeout http-keep-alive 10s
  timeout check           10s
  maxconn                 3000
listen api-server-6443 (1)
  bind *:6443
  mode tcp
  server bootstrap bootstrap.ocp4.example.com:6443 check inter 1s backup (2)
  server master0 master0.ocp4.example.com:6443 check inter 1s
  server master1 master1.ocp4.example.com:6443 check inter 1s
  server master2 master2.ocp4.example.com:6443 check inter 1s
listen machine-config-server-22623 (3)
  bind *:22623
  mode tcp
  option  httpchk GET /readyz HTTP/1.0
  option  log-health-checks
  balance roundrobin
  server bootstrap bootstrap.ocp4.example.com:6443 verify none check check-ssl inter 10s fall 2
rise 3 backup (4)
  server master0 master0.ocp4.example.com:6443 weight 1 verify none check check-ssl inter 10s
fall 2 rise 3
  server master1 master1.ocp4.example.com:6443 weight 1 verify none check check-ssl inter 10s
fall 2 rise 3
  server master2 master2.ocp4.example.com:6443 weight 1 verify none check check-ssl inter 10s
fall 2 rise 3
listen ingress-router-443 (5)
  bind *:443
  mode tcp
  balance source
  server worker0 worker0.ocp4.example.com:443 check inter 1s
  server worker1 worker1.ocp4.example.com:443 check inter 1s
```

```
listen ingress-router-80 6
  bind *:80
  mode tcp
  balance source
  server worker0 worker0.ocp4.example.com:80 check inter 1s
  server worker1 worker1.ocp4.example.com:80 check inter 1s
```

1 Port **6443** handles the Kubernetes API traffic and points to the control plane machines.

2 4 The bootstrap entries must be in place before the OpenShift Container Platform cluster installation and they must be removed after the bootstrap process is complete.

3 Port **22623** handles the machine config server traffic and points to the control plane machines.

5 Port **443** handles the HTTPS traffic and points to the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.

6 Port **80** handles the HTTP traffic and points to the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.

NOTE

If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application Ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes.

TIP

If you are using HAProxy as a load balancer, you can check that the **haproxy** process is listening on ports **6443**, **22623**, **443**, and **80** by running **netstat -nltupe** on the HAProxy node.

11.2.4. Preparing the user-provisioned infrastructure

Before you install OpenShift Container Platform on user-provisioned infrastructure, you must prepare the underlying infrastructure.

This section provides details about the high-level steps required to set up your cluster infrastructure in preparation for an OpenShift Container Platform installation. This includes configuring IP networking and network connectivity for your cluster nodes, enabling the required ports through your firewall, and setting up the required DNS and load balancing infrastructure.

After preparation, your cluster infrastructure must meet the requirements outlined in the *Requirements for a cluster with user-provisioned infrastructure* section.

Prerequisites

- You have reviewed the OpenShift Container Platform 4.x Tested Integrations page.
- You have reviewed the infrastructure requirements detailed in the *Requirements for a cluster with user-provisioned infrastructure* section.

Procedure

1. If you are using DHCP to provide the IP networking configuration to your cluster nodes, configure your DHCP service.

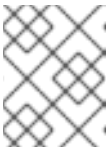
    a. Add persistent IP addresses for the nodes to your DHCP server configuration. In your configuration, match the MAC address of the relevant network interface to the intended IP address for each node.

    b. When you use DHCP to configure IP addressing for the cluster machines, the machines also obtain the DNS server information through DHCP. Define the persistent DNS server address that is used by the cluster nodes through your DHCP server configuration.

NOTE

If you are not using a DHCP service, you must provide the IP networking configuration and the address of the DNS server to the nodes at RHCOS install time. These can be passed as boot arguments if you are installing from an ISO image. See the *Installing RHCOS and starting the OpenShift Container Platform bootstrap process* section for more information about static IP provisioning and advanced networking options.

    c. Define the hostnames of your cluster nodes in your DHCP server configuration. See the *Setting the cluster node hostnames through DHCP* section for details about hostname considerations.

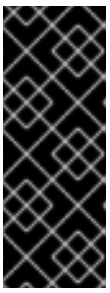


NOTE

If you are not using a DHCP service, the cluster nodes obtain their hostname through a reverse DNS lookup.

2. Ensure that your network infrastructure provides the required network connectivity between the cluster components. See the *Networking requirements for user-provisioned infrastructure* section for details about the requirements.

3. Configure your firewall to enable the ports required for the OpenShift Container Platform cluster components to communicate. See *Networking requirements for user-provisioned infrastructure* section for details about the ports that are required.



IMPORTANT

By default, port **1936** is accessible for an OpenShift Container Platform cluster, because each control plane node needs access to this port.

Avoid using the Ingress load balancer to expose this port, because doing so might result in the exposure of sensitive information, such as statistics and metrics, related to Ingress Controllers.

4. Setup the required DNS infrastructure for your cluster.

    a. Configure DNS name resolution for the Kubernetes API, the application wildcard, the bootstrap machine, the control plane machines, and the compute machines.

    b. Configure reverse DNS resolution for the Kubernetes API, the bootstrap machine, the control plane machines, and the compute machines.

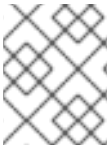
See the *User-provisioned DNS requirements* section for more information about the OpenShift Container Platform DNS requirements.

5. Validate your DNS configuration.

   a. From your installation node, run DNS lookups against the record names of the Kubernetes API, the wildcard routes, and the cluster nodes. Validate that the IP addresses in the responses correspond to the correct components.

   b. From your installation node, run reverse DNS lookups against the IP addresses of the load balancer and the cluster nodes. Validate that the record names in the responses correspond to the correct components.
   See the *Validating DNS resolution for user-provisioned infrastructure* section for detailed DNS validation steps.

6. Provision the required API and application ingress load balancing infrastructure. See the *Load balancing requirements for user-provisioned infrastructure* section for more information about the requirements.



NOTE

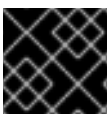
Some load balancing solutions require the DNS name resolution for the cluster nodes to be in place before the load balancing is initialized.

Additional resources

- Requirements for a cluster with user-provisioned infrastructure
- Installing RHCOS and starting the OpenShift Container Platform bootstrap process
- Setting the cluster node hostnames through DHCP
- Advanced RHCOS installation configuration
- Networking requirements for user-provisioned infrastructure
- User-provisioned DNS requirements
- Validating DNS resolution for user-provisioned infrastructure
- Load balancing requirements for user-provisioned infrastructure

11.2.5. Validating DNS resolution for user-provisioned infrastructure

You can validate your DNS configuration before installing OpenShift Container Platform on user-provisioned infrastructure.



IMPORTANT

The validation steps detailed in this section must succeed before you install your cluster.

Prerequisites

- You have configured the required DNS records for your user-provisioned infrastructure.

Procedure

1. From your installation node, run DNS lookups against the record names of the Kubernetes API, the wildcard routes, and the cluster nodes. Validate that the IP addresses contained in the responses correspond to the correct components.

   a. Perform a lookup against the Kubernetes API record name. Check that the result points to the IP address of the API load balancer:

   ```
   $ dig +noall +answer @<nameserver_ip> api.<cluster_name>.<base_domain>
   ```
   (1)

   (1) Replace **<nameserver_ip>** with the IP address of the nameserver, **<cluster_name>** with your cluster name, and **<base_domain>** with your base domain name.

   Example output

   ```
   api.ocp4.example.com.  604800 IN A 192.168.1.5
   ```

   b. Perform a lookup against the Kubernetes internal API record name. Check that the result points to the IP address of the API load balancer:

   ```
   $ dig +noall +answer @<nameserver_ip> api-int.<cluster_name>.<base_domain>
   ```

   Example output

   ```
   api-int.ocp4.example.com.  604800 IN A 192.168.1.5
   ```

   c. Test an example ***.apps.<cluster_name>.<base_domain>** DNS wildcard lookup. All of the application wildcard lookups must resolve to the IP address of the application ingress load balancer:

   ```
   $ dig +noall +answer @<nameserver_ip> random.apps.<cluster_name>.<base_domain>
   ```

   Example output

   ```
   random.apps.ocp4.example.com.  604800 IN A 192.168.1.5
   ```

   NOTE

   In the example outputs, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

   You can replace **random** with another wildcard value. For example, you can query the route to the OpenShift Container Platform console:

   ```
   $ dig +noall +answer @<nameserver_ip> console-openshift-console.apps.
   <cluster_name>.<base_domain>
   ```

   Example output

```
console-openshift-console.apps.ocp4.example.com. 604800 IN A 192.168.1.5
```

d. Run a lookup against the bootstrap DNS record name. Check that the result points to the IP address of the bootstrap node:

```
$ dig +noall +answer @<nameserver_ip> bootstrap.<cluster_name>.<base_domain>
```

Example output

```
bootstrap.ocp4.example.com.  604800 IN A 192.168.1.96
```

e. Use this method to perform lookups against the DNS record names for the control plane and compute nodes. Check that the results correspond to the IP addresses of each node.

2. From your installation node, run reverse DNS lookups against the IP addresses of the load balancer and the cluster nodes. Validate that the record names contained in the responses correspond to the correct components.

a. Perform a reverse lookup against the IP address of the API load balancer. Check that the response includes the record names for the Kubernetes API and the Kubernetes internal API:

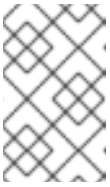
```
$ dig +noall +answer @<nameserver_ip> -x 192.168.1.5
```

Example output

```
5.1.168.192.in-addr.arpa. 604800 IN PTR api-int.ocp4.example.com. 1
5.1.168.192.in-addr.arpa. 604800 IN PTR api.ocp4.example.com. 2
```

1 Provides the record name for the Kubernetes internal API.

2 Provides the record name for the Kubernetes API.



NOTE

A PTR record is not required for the OpenShift Container Platform application wildcard. No validation step is needed for reverse DNS resolution against the IP address of the application ingress load balancer.

b. Perform a reverse lookup against the IP address of the bootstrap node. Check that the result points to the DNS record name of the bootstrap node:

```
$ dig +noall +answer @<nameserver_ip> -x 192.168.1.96
```

Example output

```
96.1.168.192.in-addr.arpa. 604800 IN PTR bootstrap.ocp4.example.com.
```

c. Use this method to perform reverse lookups against the IP addresses for the control plane and compute nodes. Check that the results correspond to the DNS record names of each node.

Additional resources

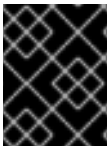
- User-provisioned DNS requirements
- Load balancing requirements for user-provisioned infrastructure

11.2.6. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the **~/.ssh/authorized_keys** list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The **./openshift-install gather** command also requires the SSH public key to be in place on the cluster nodes.



IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.

NOTE

You must use a local key, not one that you configured with platform-specific approaches such as AWS key pairs.

Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N '' -f <path>/<file_name> 1
```

1 Specify the path and file name, such as **~/.ssh/id_ed25519**, of the new SSH key. If you have an existing key pair, ensure your public key is in the your **~/.ssh** directory.

NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS validated or Modules In Process cryptographic libraries on the **x86_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the **~/.ssh/id_ed25519.pub** public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the **./openshift-install gather** command.

NOTE

On some distributions, default SSH private key identities such as **~/.ssh/id_rsa** and **~/.ssh/id_dsa** are managed automatically.

   a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

Example output

```
Agent pid 31874
```

NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

1 Specify the path and file name for your SSH private key, such as **~/.ssh/id_ed25519**

Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program. If you install a cluster on infrastructure that you provision, you must provide the key to the installation program.

Additional resources

- Verifying node health

11.2.7. Obtaining the installation program

Before you install OpenShift Container Platform, download the installation file on a local computer.

Prerequisites

- You have a computer that runs Linux or macOS, with 500 MB of local disk space.

Procedure

1. Access the Infrastructure Provider page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program that corresponds with your host operating system and architecture, and place the file in the directory where you will store the installation configuration files.

IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.

IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation pull secret from the Red Hat OpenShift Cluster Manager . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

11.2.8. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.

IMPORTANT

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.11. Download and install the new version of **oc**.

Installing the OpenShift CLI on Linux

You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the architecture in the **Product Variant** drop-down menu.
3. Select the appropriate version in the **Version** drop-down menu.
4. Click **Download Now** next to the **OpenShift v4.11 Linux Client** entry and save the file.
5. Unpack the archive:

```
$ tar xvf <file>
```

6. Place the **oc** binary in a directory that is on your **PATH**.
   To check your **PATH**, execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.
   To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
C:\> oc <command>
```

Installing the OpenShift CLI on macOS

You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 macOS Client** entry and save the file.

NOTE

For macOS arm64, choose the **OpenShift v4.11 macOS arm64 Client** entry.

4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your PATH.
To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

11.2.9. Manually creating the installation configuration file

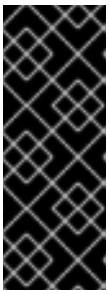
Prerequisites

- You have an SSH public key on your local machine to provide to the installation program. The key will be used for SSH authentication onto your cluster nodes for debugging and disaster recovery.
- You have obtained the OpenShift Container Platform installation program and the pull secret for your cluster.

Procedure

1. Create an installation directory to store your required installation assets in:

```
$ mkdir <installation_directory>
```



IMPORTANT

You must create a directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

2. Customize the sample **install-config.yaml** file template that is provided and save it in the **<installation_directory>**.

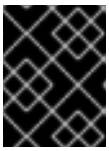
NOTE

You must name this configuration file **install-config.yaml**.

NOTE

For some platform types, you can alternatively run **./openshift-install create install-config --dir <installation_directory>** to generate an **install-config.yaml** file. You can provide details about your cluster configuration at the prompts.

3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.



IMPORTANT

The **install-config.yaml** file is consumed during the next step of the installation process. You must back it up now.

11.2.9.1. Installation configuration parameters

Before you deploy an OpenShift Container Platform cluster, you provide a customized **install-config.yaml** installation configuration file that describes the details for your environment.

NOTE

After installation, you cannot modify these parameters in the **install-config.yaml** file.

11.2.9.1.1. Required configuration parameters

Required installation configuration parameters are described in the following table:

Table 11.9. Required parameters

Parameter	Description	Values
apiVersion	The API version for the **install-config.yaml** content. The current version is **v1**. The installer may also support older API versions.	String

Parameter	Description	Values
baseDomain	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the **baseDomain** and **metadata.name** parameter values that uses the **<metadata.name>.<baseDomain>** format.	A fully-qualified domain or subdomain name, such as **example.com**.
metadata	Kubernetes resource **ObjectMeta**, from which only the **name** parameter is consumed.	Object
metadata.name	The name of the cluster. DNS records for the cluster are all subdomains of **{{.metadata.name}}.{{.baseDomain}}**.	String of lowercase letters and hyphens (**-**), such as **dev**.
platform	The configuration for the specific platform upon which to perform the installation: **alibabacloud**, **aws**, **baremetal**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**. For additional information about **platform.<platform>** parameters, consult the table for your specific platform that follows.	Object

Parameter	Description	Values
pullSecret	Get a pull secret from the Red Hat OpenShift Cluster Manager to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	<pre>{ "auths":{ "cloud.openshift.com":{ "auth":"b3Blb=", "email":"you@example.com" }, "quay.io":{ "auth":"b3Blb=", "email":"you@example.com" } } }</pre>

11.2.9.1.2. Network configuration parameters

You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

- If you use the OVN-Kubernetes cluster network provider, both IPv4 and IPv6 address families are supported.
- If you use the OpenShift SDN cluster network provider, only the IPv4 address family is supported.

If you configure your cluster to use both IP address families, review the following requirements:

- Both IP families must use the same network interface for the default gateway.
- Both IP families must have the default gateway.
- You must specify IPv4 and IPv6 addresses in the same order for all network configuration parameters. For example, in the following configuration IPv4 addresses are listed before IPv6 addresses.

```
networking:
  clusterNetwork:
  - cidr: 10.128.0.0/14
    hostPrefix: 23
  - cidr: fd00:10:128::/56
    hostPrefix: 64
  serviceNetwork:
  - 172.30.0.0/16
  - fd00:172:16::/112
```

NOTE

Globalnet is not supported with Red Hat OpenShift Data Foundation disaster recovery solutions. For regional disaster recovery scenarios, ensure that you use a nonoverlapping range of private IP addresses for the cluster and service networks in each cluster.

Table 11.10. Network parameters

Parameter	Description	Values
networking	The configuration for the cluster network.	Object  **NOTE** You cannot modify parameters specified by the **networking** object after installation.
networking.networkType	The cluster network provider Container Network Interface (CNI) cluster network provider to install.	Either **OpenShiftSDN** or **OVNKubernetes**. **OpenShiftSDN** is a CNI provider for all-Linux networks. **OVNKubernetes** is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is **OpenShiftSDN**.
networking.clusterNetwork	The IP address blocks for pods. The default value is **10.128.0.0/14** with a host prefix of **/23**. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: `networking:` `  clusterNetwork:` `  - cidr: 10.128.0.0/14` `  hostPrefix: 23` `  - cidr: fd01::/48` `  hostPrefix: 64`
networking.clusterNetwork.cidr	Required if you use **networking.clusterNetwork**. An IP address block. If you use the OpenShift SDN network provider, specify an IPv4 network. If you use the OVN-Kubernetes network provider, you can specify IPv4 and IPv6 networks.	An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between **0** and **32**. The prefix length for an IPv6 block is between **0** and **128**. For example, **10.128.0.0/14** or **fd01::/48**.
networking.clusterNetwork.hostPrefix	The subnet prefix length to assign to each individual node. For example, if **hostPrefix** is set to **23** then each node is assigned a **/23** subnet out of the given **cidr**. A **hostPrefix** value of **23** provides 510 (2^(32 - 23) - 2) pod IP addresses.	A subnet prefix. For an IPv4 network the default value is **23**. For an IPv6 network the default value is **64**. The default value is also the minimum value for IPv6.

Parameter	Description	Values
networking.serviceNetwork	The IP address block for services. The default value is **172.30.0.0/16**. The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network. If you use the OVN-Kubernetes network provider, you can specify an IP address block for both of the IPv4 and IPv6 address families.	An array with an IP address block in CIDR format. For example: networking: serviceNetwork: - 172.30.0.0/16 - fd02::/112
networking.machineNetwork	The IP address blocks for machines. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: networking: machineNetwork: - cidr: 10.0.0.0/16
networking.machineNetwork.cidr	Required if you use **networking.machineNetwork**. An IP address block. The default value is **10.0.0.0/16** for all platforms other than libvirt. For libvirt, the default value is **192.168.126.0/24**.	An IP network block in CIDR notation. For example, **10.0.0.0/16** or **fd00::/48**. NOTE Set the **networking.machineNetwork** to match the CIDR that the preferred NIC resides in.

11.2.9.1.3. Optional configuration parameters

Optional installation configuration parameters are described in the following table:

Table 11.11. Optional parameters

Parameter	Description	Values
additionalTrustBundle	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String

Parameter	Description	Values
capabilities	Controls the installation of optional core cluster components. You can reduce the footprint of your OpenShift Container Platform cluster by disabling optional components.	String array
capabilities.baselineCapabilitySet	Selects an initial set of optional capabilities to enable. Valid values are **None**, **v4.11** and **vCurrent**. **v4.11** enables the **baremetal** Operator, the **marketplace** Operator, and the **openshift-samples** content. **vCurrent** installs the recommended set of capabilities for the current version of OpenShift Container Platform. The default value is **vCurrent**.	String
capabilities.additionalEnabledCapabilities	Extends the set of optional capabilities beyond what you specify in **baselineCapabilitySet**. Valid values are **baremetal**, **marketplace** and **openshift-samples**. You may specify multiple capabilities in this parameter.	String array
cgroupsV2	Enables Linux control groups version 2 (cgroups v2) on specific nodes in your cluster. The OpenShift Container Platform process for enabling cgroups v2 disables all cgroup version 1 controllers and hierarchies. The OpenShift Container Platform cgroups version 2 feature is in Developer Preview and is not supported by Red Hat at this time.	**true**
compute	The configuration for the machines that comprise the compute nodes.	Array of **MachinePool** objects.
compute.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** and **arm64**.	String

Parameter	Description	Values
compute.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  **IMPORTANT** If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
compute.name	Required if you use **compute**. The name of the machine pool.	**worker**
compute.platform	Required if you use **compute**. Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the **controlPlane.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
compute.replicas	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to **2**. The default value is **3**.
controlPlane	The configuration for the machines that comprise the control plane.	Array of **MachinePool** objects.
controlPlane.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** and **arm64**.	String

Parameter	Description	Values
controlPlane.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  **IMPORTANT** If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
controlPlane.name	Required if you use **controlPlane**. The name of the machine pool.	**master**
controlPlane.platform	Required if you use **controlPlane**. Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the **compute.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
controlPlane.replicas	The number of control plane machines to provision.	The only supported value is **3**, which is the default value.

Parameter	Description	Values
credentialsMode	The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported.  **NOTE** Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the *Cloud Credential Operator* entry in the *Cluster Operators reference* content.  **NOTE** If your AWS account has service control policies (SCP) enabled, you must configure the **credentialsMode** parameter to **Mint**, **Passthrough** or **Manual**.	**Mint**, **Passthrough**, **Manual** or an empty string (**""**).

Parameter	Description	Values
fips	Enable or disable FIPS mode. The default is **false** (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.  **IMPORTANT** To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.  **NOTE** If you are using Azure File storage, you cannot enable FIPS mode.	**false** or **true**
imageContentSources	Sources and repositories for the release-image content.	Array of objects. Includes a **source** and, optionally, **mirrors**, as described in the following rows of this table.
imageContentSources.source	Required if you use **imageContentSources**. Specify the repository that users refer to, for example, in image pull specifications.	String

Parameter	Description	Values
imageContentSources.mirrors	Specify one or more repositories that may also contain the same images.	Array of strings
publish	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	**Internal** or **External**. The default value is **External**. Setting this field to **Internal** is not supported on non-cloud platforms and IBM Cloud VPC.  **IMPORTANT** If the value of the field is set to **Internal**, the cluster will become non-functional. For more information, refer to BZ#1953035.
sshKey	The SSH key to authenticate access to your cluster machines.  **NOTE** For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.	For example, **sshKey: ssh-ed25519 AAAA..**.

11.2.9.2. Sample install-config.yaml file for bare metal

You can customize the **install-config.yaml** file to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.

```
apiVersion: v1
baseDomain: example.com (1)
compute: (2)
- hyperthreading: Enabled (3)
  name: worker
  replicas: 0 (4)
controlPlane: (5)
  hyperthreading: Enabled (6)
  name: master
  replicas: 3 (7)
```

```
metadata:
  name: test 8
networking:
  clusterNetwork:
  - cidr: 10.128.0.0/14 9
    hostPrefix: 23 10
  networkType: OpenShiftSDN
  serviceNetwork: 11
  - 172.30.0.0/16
platform:
  none: {} 12
fips: false 13
pullSecret: '{"auths": ...}' 14
sshKey: 'ssh-ed25519 AAAA...' 15
```

1 The base domain of the cluster. All DNS records must be sub-domains of this base and include the cluster name.

2 5 The **controlPlane** section is a single mapping, but the **compute** section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, **-**, and the first line of the **controlPlane** section must not. Only one control plane pool is used.

3 6 Specifies whether to enable or disable simultaneous multithreading (SMT), or hyperthreading. By default, SMT is enabled to increase the performance of the cores in your machines. You can disable it by setting the parameter value to **Disabled**. If you disable SMT, you must disable it in all cluster machines; this includes both control plane and compute machines.

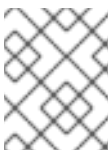
NOTE

Simultaneous multithreading (SMT) is enabled by default. If SMT is not enabled in your BIOS settings, the **hyperthreading** parameter has no effect.

IMPORTANT

If you disable **hyperthreading**, whether in the BIOS or in the **install-config.yaml** file, ensure that your capacity planning accounts for the dramatically decreased machine performance.

4 You must set this value to **0** when you install OpenShift Container Platform on user-provisioned infrastructure. In installer-provisioned installations, the parameter controls the number of compute machines that the cluster creates and manages for you. In user-provisioned installations, you must manually deploy the compute machines before you finish installing the cluster.



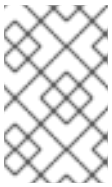
NOTE

If you are installing a three-node cluster, do not deploy any compute machines when you install the Red Hat Enterprise Linux CoreOS (RHCOS) machines.

7 The number of control plane machines that you add to the cluster. Because the cluster uses these values as the number of etcd endpoints in the cluster, the value must match the number of control plane machines that you deploy.

8 The cluster name that you specified in your DNS records.

9 A block of IP addresses from which pod IP addresses are allocated. This block must not overlap with existing physical networks. These IP addresses are used for the pod network. If you need to access the pods from an external network, you must configure load balancers and routers to manage the traffic.



NOTE

Class E CIDR range is reserved for a future use. To use the Class E CIDR range, you must ensure your networking environment accepts the IP addresses within the Class E CIDR range.

10 The subnet prefix length to assign to each individual node. For example, if **hostPrefix** is set to **23**, then each node is assigned a /**23** subnet out of the given **cidr**, which allows for 510 (2^(32 - 23) - 2) pod IP addresses. If you are required to provide access to nodes from an external network, configure load balancers and routers to manage the traffic.

11 The IP address pool to use for service IP addresses. You can enter only one IP address pool. This block must not overlap with existing physical networks. If you need to access the services from an external network, configure load balancers and routers to manage the traffic.

12 You must set the platform to **none**. You cannot provide additional platform configuration variables for your platform.

IMPORTANT

Clusters that are installed with the platform type **none** are unable to use some features, such as managing compute machines with the Machine API. This limitation applies even if the compute machines that are attached to the cluster are installed on a platform that would normally support the feature. This parameter cannot be changed after installation.

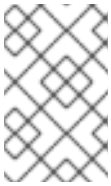
13 Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.

IMPORTANT

To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.

14 The pull secret from the Red Hat OpenShift Cluster Manager . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

15 The SSH public key for the **core** user in Red Hat Enterprise Linux CoreOS (RHCOS).



NOTE

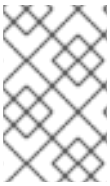
For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

Additional resources

- See Load balancing requirements for user-provisioned infrastructure for more information on the API and application ingress load balancing requirements.

11.2.9.3. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

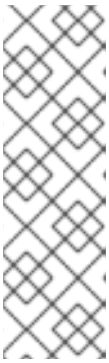


NOTE

For bare metal installations, if you do not assign node IP addresses from the range that is specified in the **networking.machineNetwork[].cidr** field in the **install-config.yaml** file, you must include them in the **proxy.noProxy** field.

Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.



NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
```

```
additionalTrustBundle: | 4
  -----BEGIN CERTIFICATE-----
  <MY_TRUSTED_CA_CERT>
  -----END CERTIFICATE-----
```

1. A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
2. A proxy URL to use for creating HTTPS connections outside the cluster.
3. A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use * to bypass the proxy for all destinations.
4. If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace that contains one or more additional CA certificates that are required for proxying HTTPS connections. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges these contents with the Red Hat Enterprise Linux CoreOS (RHCOS) trust bundle, and this config map is referenced in the **trustedCA** field of the **Proxy** object. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.

NOTE

The installation program does not support the proxy **readinessEndpoints** field.

NOTE

If the installer times out, restart and then complete the deployment by using the **wait-for** command of the installer. For example:

```
$ ./openshift-install wait-for install-complete --log-level debug
```

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.

NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

11.2.9.4. Configuring a three-node cluster

Optionally, you can deploy zero compute machines in a bare metal cluster that consists of three control plane machines only. This provides smaller, more resource efficient clusters for cluster administrators and developers to use for testing, development, and production.

In three-node OpenShift Container Platform environments, the three control plane machines are schedulable, which means that your application workloads are scheduled to run on them.

Prerequisites

- You have an existing **install-config.yaml** file.

Procedure

- Ensure that the number of compute replicas is set to **0** in your **install-config.yaml** file, as shown in the following **compute** stanza:

```
compute:
- name: worker
  platform: {}
  replicas: 0
```

NOTE

You must set the value of the **replicas** parameter for the compute machines to **0** when you install OpenShift Container Platform on user-provisioned infrastructure, regardless of the number of compute machines you are deploying. In installer-provisioned installations, the parameter controls the number of compute machines that the cluster creates and manages for you. This does not apply to user-provisioned installations, where the compute machines are deployed manually.

For three-node cluster installations, follow these next steps:

- If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes. See the *Load balancing requirements for user-provisioned infrastructure* section for more information.

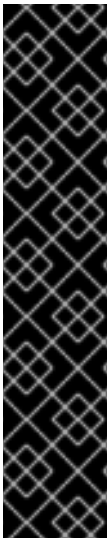
- When you create the Kubernetes manifest files in the following procedure, ensure that the **mastersSchedulable** parameter in the **<installation_directory>/manifests/cluster-scheduler-02-config.yml** file is set to **true**. This enables your application workloads to run on the control plane nodes.

- Do not deploy any compute nodes when you create the Red Hat Enterprise Linux CoreOS (RHCOS) machines.

11.2.10. Creating the Kubernetes manifest and Ignition config files

Because you must modify some cluster definition files and manually start the cluster machines, you must generate the Kubernetes manifest and Ignition config files that the cluster needs to configure the machines.

The installation configuration file transforms into the Kubernetes manifests. The manifests wrap into the Ignition configuration files, which are later used to configure the cluster machines.



IMPORTANT

- The Ignition config files that the OpenShift Container Platform installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

Prerequisites

- You obtained the OpenShift Container Platform installation program.
- You created the **install-config.yaml** installation configuration file.

Procedure

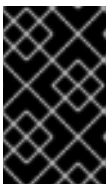
1. Change to the directory that contains the OpenShift Container Platform installation program and generate the Kubernetes manifests for the cluster:

```
$ ./openshift-install create manifests --dir <installation_directory> 1
```

1 For **<installation_directory>**, specify the installation directory that contains the **install-config.yaml** file you created.

WARNING

If you are installing a three-node cluster, skip the following step to allow the control plane nodes to be schedulable.



IMPORTANT

When you configure control plane nodes from the default unschedulable to schedulable, additional subscriptions are required. This is because control plane nodes then become compute nodes.

2. Check that the **mastersSchedulable** parameter in the **<installation_directory>/manifests/cluster-scheduler-02-config.yml** Kubernetes manifest file is set to **false**. This setting prevents pods from being scheduled on the control plane machines:

   a. Open the **<installation_directory>/manifests/cluster-scheduler-02-config.yml** file.

b. Locate the **mastersSchedulable** parameter and ensure that it is set to **false**.

c. Save and exit the file.

3. To create the Ignition configuration files, run the following command from the directory that contains the installation program:

```
$ ./openshift-install create ignition-configs --dir <installation_directory> 1
```

1 For **<installation_directory>**, specify the same installation directory.

Ignition config files are created for the bootstrap, control plane, and compute nodes in the installation directory. The **kubeadmin-password** and **kubeconfig** files are created in the **./<installation_directory>/auth** directory:

```
.
├── auth
│   ├── kubeadmin-password
│   └── kubeconfig
├── bootstrap.ign
├── master.ign
├── metadata.json
└── worker.ign
```

Additional resources

- See Recovering from expired control plane certificates for more information about recovering kubelet certificates.

11.2.11. Installing RHCOS and starting the OpenShift Container Platform bootstrap process

To install OpenShift Container Platform on bare metal infrastructure that you provision, you must install Red Hat Enterprise Linux CoreOS (RHCOS) on the machines. When you install RHCOS, you must provide the Ignition config file that was generated by the OpenShift Container Platform installation program for the type of machine you are installing. If you have configured suitable networking, DNS, and load balancing infrastructure, the OpenShift Container Platform bootstrap process begins automatically after the RHCOS machines have rebooted.

To install RHCOS on the machines, follow either the steps to use an ISO image or network PXE booting.

NOTE

The compute node deployment steps included in this installation document are RHCOS-specific. If you choose instead to deploy RHEL-based compute nodes, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks. Only RHEL 8 compute machines are supported.

You can configure RHCOS during ISO and PXE installations by using the following methods:

- Kernel arguments: You can use kernel arguments to provide installation-specific information. For example, you can specify the locations of the RHCOS installation files that you uploaded to

your HTTP server and the location of the Ignition config file for the type of node you are installing. For a PXE installation, you can use the **APPEND** parameter to pass the arguments to the kernel of the live installer. For an ISO installation, you can interrupt the live installation boot process to add the kernel arguments. In both installation cases, you can use special **coreos.inst.*** arguments to direct the live installer, as well as standard installation boot arguments for turning standard kernel services on or off.

- Ignition configs: OpenShift Container Platform Ignition config files (***.ign**) are specific to the type of node you are installing. You pass the location of a bootstrap, control plane, or compute node Ignition config file during the RHCOS installation so that it takes effect on first boot. In special cases, you can create a separate, limited Ignition config to pass to the live system. That Ignition config could do a certain set of tasks, such as reporting success to a provisioning system after completing installation. This special Ignition config is consumed by the **coreos-installer** to be applied on first boot of the installed system. Do not provide the standard control plane and compute node Ignition configs to the live ISO directly.

- **coreos-installer**: You can boot the live ISO installer to a shell prompt, which allows you to prepare the permanent system in a variety of ways before first boot. In particular, you can run the **coreos-installer** command to identify various artifacts to include, work with disk partitions, and set up networking. In some cases, you can configure features on the live system and copy them to the installed system.

Whether to use an ISO or PXE install depends on your situation. A PXE install requires an available DHCP service and more preparation, but can make the installation process more automated. An ISO install is a more manual process and can be inconvenient if you are setting up more than a few machines.

NOTE

As of OpenShift Container Platform 4.6, the RHCOS ISO and other installation artifacts provide support for installation on disks with 4K sectors.

11.2.11.1. Installing RHCOS by using an ISO image

You can use an ISO image to install RHCOS on the machines.

Prerequisites

- You have created the Ignition config files for your cluster.
- You have configured suitable network, DNS and load balancing infrastructure.
- You have an HTTP server that can be accessed from your computer, and from the machines that you create.
- You have reviewed the *Advanced RHCOS installation configuration* section for different ways to configure features, such as networking and disk partitioning.

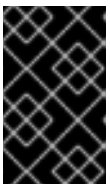
Procedure

1. Obtain the SHA512 digest for each of your Ignition config files. For example, you can use the following on a system running Linux to get the SHA512 digest for your **bootstrap.ign** Ignition config file:

```
$ sha512sum <installation_directory>/bootstrap.ign
```

The digests are provided to the **coreos-installer** in a later step to validate the authenticity of the Ignition config files on the cluster nodes.

2. Upload the bootstrap, control plane, and compute node Ignition config files that the installation program created to your HTTP server. Note the URLs of these files.



IMPORTANT

You can add or change configuration settings in your Ignition configs before saving them to your HTTP server. If you plan to add more compute machines to your cluster after you finish installation, do not delete these files.

3. From the installation host, validate that the Ignition config files are available on the URLs. The following example gets the Ignition config file for the bootstrap node:

```
$ curl -k http://<HTTP_server>/bootstrap.ign 1
```

Example output

```
  % Total    % Received % Xferd  Average Speed   Time    Time     Time  Current
                                 Dload  Upload   Total   Spent    Left  Speed
  0     0    0     0    0     0      0      0 --:--:-- --:--:-- --:--:--     0{"ignition":
{"version":"3.2.0"},"passwd":{"users":[{"name":"core","sshAuthorizedKeys":["ssh-rsa...
```

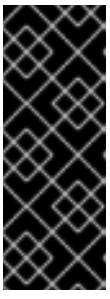
Replace **bootstrap.ign** with **master.ign** or **worker.ign** in the command to validate that the Ignition config files for the control plane and compute nodes are also available.

4. Although it is possible to obtain the RHCOS images that are required for your preferred method of installing operating system instances from the RHCOS image mirror page, the recommended way to obtain the correct version of your RHCOS images are from the output of **openshift-install** command:

```
$ openshift-install coreos print-stream-json | grep '\.iso[^.]'
```

Example output

```
"location": "<url>/art/storage/releases/rhcos-4.11-aarch64/<release>/aarch64/rhcos-
<release>-live.aarch64.iso",
"location": "<url>/art/storage/releases/rhcos-4.11-ppc64le/<release>/ppc64le/rhcos-
<release>-live.ppc64le.iso",
"location": "<url>/art/storage/releases/rhcos-4.11-s390x/<release>/s390x/rhcos-<release>-
live.s390x.iso",
"location": "<url>/art/storage/releases/rhcos-4.11/<release>/x86_64/rhcos-<release>-
live.x86_64.iso",
```



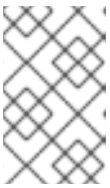
IMPORTANT

The RHCOS images might not change with every release of OpenShift Container Platform. You must download images with the highest version that is less than or equal to the OpenShift Container Platform version that you install. Use the image versions that match your OpenShift Container Platform version if they are available. Use only ISO images for this procedure. RHCOS qcow2 images are not supported for this installation type.

ISO file names resemble the following example:

rhcos-<version>-live.<architecture>.iso

5. Use the ISO to start the RHCOS installation. Use one of the following installation options:
   - Burn the ISO image to a disk and boot it directly.
   - Use ISO redirection by using a lights-out management (LOM) interface.
6. Boot the RHCOS ISO image without specifying any options or interrupting the live boot sequence. Wait for the installer to boot into a shell prompt in the RHCOS live environment.



NOTE

It is possible to interrupt the RHCOS installation boot process to add kernel arguments. However, for this ISO procedure you should use the **coreos-installer** command as outlined in the following steps, instead of adding kernel arguments.

7. Run the **coreos-installer** command and specify the options that meet your installation requirements. At a minimum, you must specify the URL that points to the Ignition config file for the node type, and the device that you are installing to:

```
$ sudo coreos-installer install --ignition-url=http://<HTTP_server>/<node_type>.ign <device>
--ignition-hash=sha512-<digest> 1 2
```

1 1 You must run the **coreos-installer** command by using **sudo**, because the **core** user does not have the required root privileges to perform the installation.

2 The **--ignition-hash** option is required when the Ignition config file is obtained through an HTTP URL to validate the authenticity of the Ignition config file on the cluster node. **<digest>** is the Ignition config file SHA512 digest obtained in a preceding step.

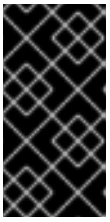
NOTE

If you want to provide your Ignition config files through an HTTPS server that uses TLS, you can add the internal certificate authority (CA) to the system trust store before running **coreos-installer**.

The following example initializes a bootstrap node installation to the **/dev/sda** device. The Ignition config file for the bootstrap node is obtained from an HTTP web server with the IP address 192.168.1.2:

```
$ sudo coreos-installer install --ignition-
url=http://192.168.1.2:80/installation_directory/bootstrap.ign /dev/sda --ignition-hash=sha512-
a5a2d43879223273c9b60af66b44202a1d1248fc01cf156c46d4a79f552b6bad47bc8cc78ddf011
6e80c59d2ea9e32ba53bc807afbca581aa059311def2c3e3b
```

8. Monitor the progress of the RHCOS installation on the console of the machine.



IMPORTANT

Be sure that the installation is successful on each node before commencing with the OpenShift Container Platform installation. Observing the installation process can also help to determine the cause of RHCOS installation issues that might arise.

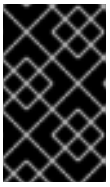
9. After RHCOS installs, you must reboot the system. During the system reboot, it applies the Ignition config file that you specified.

10. Check the console output to verify that Ignition ran.

Example command

```
Ignition: ran on 2022/03/14 14:48:33 UTC (this boot)
Ignition: user-provided config was applied
```

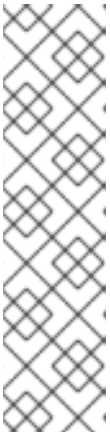
11. Continue to create the other machines for your cluster.



IMPORTANT

You must create the bootstrap and control plane machines at this time. If the control plane machines are not made schedulable, also create at least two compute machines before you install OpenShift Container Platform.

If the required network, DNS, and load balancer infrastructure are in place, the OpenShift Container Platform bootstrap process begins automatically after the RHCOS nodes have rebooted.



NOTE

RHCOS nodes do not include a default password for the **core** user. You can access the nodes by running **ssh core@<node>.<cluster_name>.<base_domain>** as a user with access to the SSH private key that is paired to the public key that you specified in your **install_config.yaml** file. OpenShift Container Platform 4 cluster nodes running RHCOS are immutable and rely on Operators to apply cluster changes. Accessing cluster nodes by using SSH is not recommended. However, when investigating installation issues, if the OpenShift Container Platform API is not available, or the kubelet is not properly functioning on a target node, SSH access might be required for debugging or disaster recovery.

11.2.11.2. Installing RHCOS by using PXE or iPXE booting

You can use PXE or iPXE booting to install RHCOS on the machines.

Prerequisites

- You have created the Ignition config files for your cluster.
- You have configured suitable network, DNS and load balancing infrastructure.
- You have configured suitable PXE or iPXE infrastructure.

- You have an HTTP server that can be accessed from your computer, and from the machines that you create.
- You have reviewed the *Advanced RHCOS installation configuration* section for different ways to configure features, such as networking and disk partitioning.

Procedure

1. Upload the bootstrap, control plane, and compute node Ignition config files that the installation program created to your HTTP server. Note the URLs of these files.

IMPORTANT

You can add or change configuration settings in your Ignition configs before saving them to your HTTP server. If you plan to add more compute machines to your cluster after you finish installation, do not delete these files.

2. From the installation host, validate that the Ignition config files are available on the URLs. The following example gets the Ignition config file for the bootstrap node:

```
$ curl -k http://<HTTP_server>/bootstrap.ign 1
```

Example output

```
  % Total    % Received % Xferd  Average Speed   Time    Time     Time  Current
                                 Dload  Upload   Total   Spent    Left  Speed
  0     0    0     0    0     0      0      0 --:--:-- --:--:-- --:--:--     0{"ignition":
{"version":"3.2.0"},"passwd":{"users":[{"name":"core","sshAuthorizedKeys":["ssh-rsa...
```

Replace **bootstrap.ign** with **master.ign** or **worker.ign** in the command to validate that the Ignition config files for the control plane and compute nodes are also available.

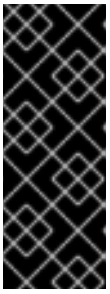
3. Although it is possible to obtain the RHCOS **kernel**, **initramfs** and **rootfs** files that are required for your preferred method of installing operating system instances from the RHCOS image mirror page, the recommended way to obtain the correct version of your RHCOS files are from the output of **openshift-install** command:

```
$ openshift-install coreos print-stream-json | grep -Eo '"https.*(kernel-|initramfs.|rootfs.)\w+
(\.img)?"'
```

Example output

```
"<url>/art/storage/releases/rhcos-4.11-aarch64/<release>/aarch64/rhcos-<release>-live-
kernel-aarch64"
"<url>/art/storage/releases/rhcos-4.11-aarch64/<release>/aarch64/rhcos-<release>-live-
initramfs.aarch64.img"
"<url>/art/storage/releases/rhcos-4.11-aarch64/<release>/aarch64/rhcos-<release>-live-
rootfs.aarch64.img"
"<url>/art/storage/releases/rhcos-4.11-ppc64le/49.84.202110081256-0/ppc64le/rhcos-
<release>-live-kernel-ppc64le"
"<url>/art/storage/releases/rhcos-4.11-ppc64le/<release>/ppc64le/rhcos-<release>-live-
initramfs.ppc64le.img"
"<url>/art/storage/releases/rhcos-4.11-ppc64le/<release>/ppc64le/rhcos-<release>-live-
```

```
rootfs.ppc64le.img"
"<url>/art/storage/releases/rhcos-4.11-s390x/<release>/s390x/rhcos-<release>-live-kernel-s390x"
"<url>/art/storage/releases/rhcos-4.11-s390x/<release>/s390x/rhcos-<release>-live-initramfs.s390x.img"
"<url>/art/storage/releases/rhcos-4.11-s390x/<release>/s390x/rhcos-<release>-live-rootfs.s390x.img"
"<url>/art/storage/releases/rhcos-4.11/<release>/x86_64/rhcos-<release>-live-kernel-x86_64"
"<url>/art/storage/releases/rhcos-4.11/<release>/x86_64/rhcos-<release>-live-initramfs.x86_64.img"
"<url>/art/storage/releases/rhcos-4.11/<release>/x86_64/rhcos-<release>-live-rootfs.x86_64.img"
```



IMPORTANT

The RHCOS artifacts might not change with every release of OpenShift Container Platform. You must download images with the highest version that is less than or equal to the OpenShift Container Platform version that you install. Only use the appropriate **kernel**, **initramfs**, and **rootfs** artifacts described below for this procedure. RHCOS QCOW2 images are not supported for this installation type.

The file names contain the OpenShift Container Platform version number. They resemble the following examples:

- **kernel**: **rhcos-<version>-live-kernel-<architecture>**
- **initramfs**: **rhcos-<version>-live-initramfs.<architecture>.img**
- **rootfs**: **rhcos-<version>-live-rootfs.<architecture>.img**

4. Upload the **rootfs**, **kernel**, and **initramfs** files to your HTTP server.

IMPORTANT

If you plan to add more compute machines to your cluster after you finish installation, do not delete these files.

5. Configure the network boot infrastructure so that the machines boot from their local disks after RHCOS is installed on them.

6. Configure PXE or iPXE installation for the RHCOS images and begin the installation. Modify one of the following example menu entries for your environment and verify that the image and Ignition files are properly accessible:

   - For PXE (**x86_64**):

```
DEFAULT pxeboot
TIMEOUT 20
PROMPT 0
LABEL pxeboot
    KERNEL http://<HTTP_server>/rhcos-<version>-live-kernel-<architecture> (1)
    APPEND initrd=http://<HTTP_server>/rhcos-<version>-live-initramfs.
```

```
<architecture>.img coreos.live.rootfs_url=http://<HTTP_server>/rhcos-<version>-live-
rootfs.<architecture>.img coreos.inst.install_dev=/dev/sda
coreos.inst.ignition_url=http://<HTTP_server>/bootstrap.ign 2 3
```

1 1 Specify the location of the live **kernel** file that you uploaded to your HTTP server. The URL must be HTTP, TFTP, or FTP; HTTPS and NFS are not supported.

2 If you use multiple NICs, specify a single interface in the **ip** option. For example, to use DHCP on a NIC that is named **eno1**, set **ip=eno1:dhcp**.

3 Specify the locations of the RHCOS files that you uploaded to your HTTP server. The **initrd** parameter value is the location of the **initramfs** file, the **coreos.live.rootfs_url** parameter value is the location of the **rootfs** file, and the **coreos.inst.ignition_url** parameter value is the location of the bootstrap Ignition config file. You can also add more kernel arguments to the **APPEND** line to configure networking or other boot options.

NOTE

This configuration does not enable serial console access on machines with a graphical console. To configure a different console, add one or more **console=** arguments to the **APPEND** line. For example, add **console=tty0 console=ttyS0** to set the first PC serial port as the primary console and the graphical console as a secondary console. For more information, see How does one set up a serial terminal and/or console in Red Hat Enterprise Linux?.

- For iPXE (**x86_64** + **aarch64**):

```
kernel http://<HTTP_server>/rhcos-<version>-live-kernel-<architecture> initrd=main
coreos.live.rootfs_url=http://<HTTP_server>/rhcos-<version>-live-rootfs.
<architecture>.img coreos.inst.install_dev=/dev/sda
coreos.inst.ignition_url=http://<HTTP_server>/bootstrap.ign 1 2
initrd --name main http://<HTTP_server>/rhcos-<version>-live-initramfs.
<architecture>.img 3
boot
```

1 Specify the locations of the RHCOS files that you uploaded to your HTTP server. The **kernel** parameter value is the location of the **kernel** file, the **initrd=main** argument is needed for booting on UEFI systems, the **coreos.live.rootfs_url** parameter value is the location of the **rootfs** file, and the **coreos.inst.ignition_url** parameter value is the location of the bootstrap Ignition config file.

2 If you use multiple NICs, specify a single interface in the **ip** option. For example, to use DHCP on a NIC that is named **eno1**, set **ip=eno1:dhcp**.

3 Specify the location of the **initramfs** file that you uploaded to your HTTP server.

NOTE

This configuration does not enable serial console access on machines with a graphical console. To configure a different console, add one or more **console=** arguments to the **kernel** line. For example, add **console=tty0 console=ttyS0** to set the first PC serial port as the primary console and the graphical console as a secondary console. For more information, see How does one set up a serial terminal and/or console in Red Hat Enterprise Linux?.

NOTE

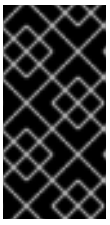
To network boot the CoreOS **kernel** on **aarch64** architecture, you need to use a version of iPXE build with the **IMAGE_GZIP** option enabled. See **IMAGE_GZIP** option in iPXE .

- For PXE (with UEFI and Grub as second stage) on **aarch64**:

```
menuentry 'Install CoreOS' {
    linux rhcos-<version>-live-kernel-<architecture>
coreos.live.rootfs_url=http://<HTTP_server>/rhcos-<version>-live-rootfs.
<architecture>.img coreos.inst.install_dev=/dev/sda
coreos.inst.ignition_url=http://<HTTP_server>/bootstrap.ign 1 2
    initrd rhcos-<version>-live-initramfs.<architecture>.img 3
}
```

1. Specify the locations of the RHCOS files that you uploaded to your HTTP/TFTP server. The **kernel** parameter value is the location of the **kernel** file on your TFTP server. The **coreos.live.rootfs_url** parameter value is the location of the **rootfs** file, and the **coreos.inst.ignition_url** parameter value is the location of the bootstrap Ignition config file on your HTTP Server.
2. If you use multiple NICs, specify a single interface in the **ip** option. For example, to use DHCP on a NIC that is named **eno1**, set **ip=eno1:dhcp**.
3. Specify the location of the **initramfs** file that you uploaded to your TFTP server.

7. Monitor the progress of the RHCOS installation on the console of the machine.



IMPORTANT

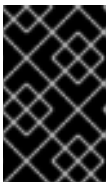
Be sure that the installation is successful on each node before commencing with the OpenShift Container Platform installation. Observing the installation process can also help to determine the cause of RHCOS installation issues that might arise.

8. After RHCOS installs, the system reboots. During reboot, the system applies the Ignition config file that you specified.
9. Check the console output to verify that Ignition ran.

Example command

```
Ignition: ran on 2022/03/14 14:48:33 UTC (this boot)
Ignition: user-provided config was applied
```

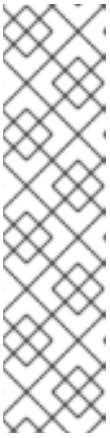
10. Continue to create the machines for your cluster.



IMPORTANT

You must create the bootstrap and control plane machines at this time. If the control plane machines are not made schedulable, also create at least two compute machines before you install the cluster.

If the required network, DNS, and load balancer infrastructure are in place, the OpenShift Container Platform bootstrap process begins automatically after the RHCOS nodes have rebooted.



NOTE

RHCOS nodes do not include a default password for the **core** user. You can access the nodes by running **ssh core@<node>.<cluster_name>.<base_domain>** as a user with access to the SSH private key that is paired to the public key that you specified in your **install_config.yaml** file. OpenShift Container Platform 4 cluster nodes running RHCOS are immutable and rely on Operators to apply cluster changes. Accessing cluster nodes by using SSH is not recommended. However, when investigating installation issues, if the OpenShift Container Platform API is not available, or the kubelet is not properly functioning on a target node, SSH access might be required for debugging or disaster recovery.

11.2.11.3. Advanced RHCOS installation configuration

A key benefit for manually provisioning the Red Hat Enterprise Linux CoreOS (RHCOS) nodes for OpenShift Container Platform is to be able to do configuration that is not available through default OpenShift Container Platform installation methods. This section describes some of the configurations that you can do using techniques that include:

- Passing kernel arguments to the live installer
- Running **coreos-installer** manually from the live system
- Customizing a live ISO or PXE boot image

The advanced configuration topics for manual Red Hat Enterprise Linux CoreOS (RHCOS) installations detailed in this section relate to disk partitioning, networking, and using Ignition configs in different ways.

11.2.11.3.1. Using advanced networking options for PXE and ISO installations

Networking for OpenShift Container Platform nodes uses DHCP by default to gather all necessary configuration settings. To set up static IP addresses or configure special settings, such as bonding, you can do one of the following:

- Pass special kernel parameters when you boot the live installer.
- Use a machine config to copy networking files to the installed system.

- Configure networking from a live installer shell prompt, then copy those settings to the installed system so that they take effect when the installed system first boots.

To configure a PXE or iPXE installation, use one of the following options:

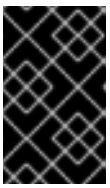
- See the "Advanced RHCOS installation reference" tables.
- Use a machine config to copy networking files to the installed system.

To configure an ISO installation, use the following procedure.

Procedure

1. Boot the ISO installer.
2. From the live system shell prompt, configure networking for the live system using available RHEL tools, such as **nmcli** or **nmtui**.
3. Run the **coreos-installer** command to install the system, adding the **--copy-network** option to copy networking configuration. For example:

```
$ sudo coreos-installer install --copy-network \
    --ignition-url=http://host/worker.ign /dev/sda
```



IMPORTANT

The **--copy-network** option only copies networking configuration found under **/etc/NetworkManager/system-connections**. In particular, it does not copy the system hostname.

4. Reboot into the installed system.

Additional resources

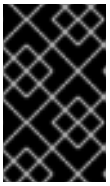
- See Getting started with nmcli and Getting started with nmtui in the RHEL 8 documentation for more information about the **nmcli** and **nmtui** tools.

11.2.11.3.2. Disk partitioning

The disk partitions are created on OpenShift Container Platform cluster nodes during the Red Hat Enterprise Linux CoreOS (RHCOS) installation. Each RHCOS node of a particular architecture uses the same partition layout, unless the default partitioning configuration is overridden. During the RHCOS installation, the size of the root file system is increased to use the remaining available space on the target device.

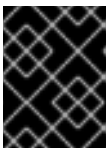
There are two cases where you might want to override the default partitioning when installing RHCOS on an OpenShift Container Platform cluster node:

- Creating separate partitions: For greenfield installations on an empty disk, you might want to add separate storage to a partition. This is officially supported for mounting **/var** or a subdirectory of **/var**, such as **/var/lib/etcd**, on a separate partition, but not both.



IMPORTANT

For disk sizes larger than 100GB, and especially disk sizes larger than 1TB, create a separate **/var** partition. See "Creating a separate **/var** partition" and this Red Hat Knowledgebase article for more information.



IMPORTANT

Kubernetes supports only two file system partitions. If you add more than one partition to the original configuration, Kubernetes cannot monitor all of them.

- Retaining existing partitions: For a brownfield installation where you are reinstalling OpenShift Container Platform on an existing node and want to retain data partitions installed from your previous operating system, there are both boot arguments and options to **coreos-installer** that allow you to retain existing data partitions.

WARNING

The use of custom partitions could result in those partitions not being monitored by OpenShift Container Platform or alerted on. If you are overriding the default partitioning, see Understanding OpenShift File System Monitoring (eviction conditions) for more information about how OpenShift Container Platform monitors your host file systems.

11.2.11.3.2.1. Creating a separate /var partition

In general, you should use the default disk partitioning that is created during the RHCOS installation. However, there are cases where you might want to create a separate partition for a directory that you expect to grow.

OpenShift Container Platform supports the addition of a single partition to attach storage to either the **/var** directory or a subdirectory of **/var**. For example:

- **/var/lib/containers**: Holds container-related content that can grow as more images and containers are added to a system.
- **/var/lib/etcd**: Holds data that you might want to keep separate for purposes such as performance optimization of etcd storage.
- **/var**: Holds data that you might want to keep separate for purposes such as auditing.

IMPORTANT

For disk sizes larger than 100GB, and especially larger than 1TB, create a separate **/var** partition.

Storing the contents of a **/var** directory separately makes it easier to grow storage for those areas as needed and reinstall OpenShift Container Platform at a later date and keep that data intact. With this method, you will not have to pull all your containers again, nor will you have to copy massive log files when you update systems.

The use of a separate partition for the /**var** directory or a subdirectory of /**var** also prevents data growth in the partitioned directory from filling up the root file system.

The following procedure sets up a separate /**var** partition by adding a machine config manifest that is wrapped into the Ignition config file for a node type during the preparation phase of an installation.

Procedure

1. On your installation host, change to the directory that contains the OpenShift Container Platform installation program and generate the Kubernetes manifests for the cluster:

```
$ openshift-install create manifests --dir <installation_directory>
```

2. Create a Butane config that configures the additional partition. For example, name the file **$HOME/clusterconfig/98-var-partition.bu**, change the disk device name to the name of the storage device on the **worker** systems, and set the storage size as appropriate. This example places the /**var** directory on a separate partition:

```
variant: openshift
version: 4.11.0
metadata:
  labels:
    machineconfiguration.openshift.io/role: worker
  name: 98-var-partition
storage:
  disks:
  - device: /dev/<device_name> 1
    partitions:
    - label: var
      start_mib: <partition_start_offset> 2
      size_mib: <partition_size> 3
  filesystems:
    - device: /dev/disk/by-partlabel/var
      path: /var
      format: xfs
      mount_options: [defaults, prjquota] 4
      with_mount_unit: true
```

1. The storage device name of the disk that you want to partition.
2. When adding a data partition to the boot disk, a minimum offset value of 25000 mebibytes is recommended. The root file system is automatically resized to fill all available space up to the specified offset. If no offset value is specified, or if the specified value is smaller than the recommended minimum, the resulting root file system will be too small, and future reinstalls of RHCOS might overwrite the beginning of the data partition.
3. The size of the data partition in mebibytes.
4. The **prjquota** mount option must be enabled for filesystems used for container storage.

NOTE

When creating a separate /**var** partition, you cannot use different instance types for compute nodes, if the different instance types do not have the same device name.

3. Create a manifest from the Butane config and save it to the **clusterconfig/openshift** directory. For example, run the following command:

```
$ butane $HOME/clusterconfig/98-var-partition.bu -o $HOME/clusterconfig/openshift/98-var-partition.yaml
```

4. Create the Ignition config files:

```
$ openshift-install create ignition-configs --dir <installation_directory> 1
```

1 For **<installation_directory>**, specify the same installation directory.

Ignition config files are created for the bootstrap, control plane, and compute nodes in the installation directory:

```
.
├── auth
│   ├── kubeadmin-password
│   └── kubeconfig
├── bootstrap.ign
├── master.ign
├── metadata.json
└── worker.ign
```

The files in the **<installation_directory>/manifest** and **<installation_directory>/openshift** directories are wrapped into the Ignition config files, including the file that contains the **98-var-partition** custom **MachineConfig** object.

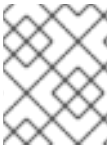
Next steps

- You can apply the custom disk partitioning by referencing the Ignition config files during the RHCOS installations.

11.2.11.3.2.2. Retaining existing partitions

For an ISO installation, you can add options to the **coreos-installer** command that cause the installer to maintain one or more existing partitions. For a PXE installation, you can add **coreos.inst.*** options to the **APPEND** parameter to preserve partitions.

Saved partitions might be data partitions from an existing OpenShift Container Platform system. You can identify the disk partitions you want to keep either by partition label or by number.



NOTE

If you save existing partitions, and those partitions do not leave enough space for RHCOS, the installation will fail without damaging the saved partitions.

Retaining existing partitions during an ISO installation

This example preserves any partition in which the partition label begins with **data** (**data***):

```
# coreos-installer install --ignition-url http://10.0.2.2:8080/user.ign \
      --save-partlabel 'data*' /dev/sda
```

The following example illustrates running the **coreos-installer** in a way that preserves the sixth (6) partition on the disk:

```
# coreos-installer install --ignition-url http://10.0.2.2:8080/user.ign \
      --save-partindex 6 /dev/sda
```

This example preserves partitions 5 and higher:

```
# coreos-installer install --ignition-url http://10.0.2.2:8080/user.ign
      --save-partindex 5- /dev/sda
```

In the previous examples where partition saving is used, **coreos-installer** recreates the partition immediately.

Retaining existing partitions during a PXE installation

This **APPEND** option preserves any partition in which the partition label begins with 'data' ('data*'):

```
coreos.inst.save_partlabel=data*
```

This **APPEND** option preserves partitions 5 and higher:

```
coreos.inst.save_partindex=5-
```

This **APPEND** option preserves partition 6:

```
coreos.inst.save_partindex=6
```

11.2.11.3.3. Identifying Ignition configs

When doing an RHCOS manual installation, there are two types of Ignition configs that you can provide, with different reasons for providing each one:

- **Permanent install Ignition config**: Every manual RHCOS installation needs to pass one of the Ignition config files generated by **openshift-installer**, such as **bootstrap.ign**, **master.ign** and **worker.ign**, to carry out the installation.

  IMPORTANT

  It is not recommended to modify these Ignition config files directly. You can update the manifest files that are wrapped into the Ignition config files, as outlined in examples in the preceding sections.

  For PXE installations, you pass the Ignition configs on the **APPEND** line using the **coreos.inst.ignition_url=** option. For ISO installations, after the ISO boots to the shell prompt, you identify the Ignition config on the **coreos-installer** command line with the **--ignition-url=**

option. In both cases, only HTTP and HTTPS protocols are supported.

- **Live install Ignition config**: This type can be created by using the **coreos-installer customize** subcommand and its various options. With this method, the Ignition config passes to the live install medium, runs immediately upon booting, and performs setup tasks before or after the RHCOS system installs to disk. This method should only be used for performing tasks that must be done once and not applied again later, such as with advanced partitioning that cannot be done using a machine config.
  For PXE or ISO boots, you can create the Ignition config and **APPEND** the **ignition.config.url=** option to identify the location of the Ignition config. You also need to append **ignition.firstboot ignition.platform.id=metal** or the **ignition.config.url** option will be ignored.

11.2.11.3.3.1. Customizing a live RHCOS ISO or PXE install

You can use the live ISO image or PXE environment to install RHCOS by injecting an Ignition config file directly into the image. This creates a customized image that you can use to provision your system.

For an ISO image, the mechanism to do this is the **coreos-installer iso customize** subcommand, which modifies the **.iso** file with your configuration. Similarly, the mechanism for a PXE environment is the **coreos-installer pxe customize** subcommand, which creates a new **initramfs** file that includes your customizations.

The **customize** subcommand is a general purpose tool that can embed other types of customizations as well. The following tasks are examples of some of the more common customizations:

- Inject custom CA certificates for when corporate security policy requires their use.
- Configure network settings without the need for kernel arguments.
- Embed arbitrary preinstall and post-install scripts or binaries.

11.2.11.3.3.2. Customizing a live RHCOS ISO image

You can customize a live RHCOS ISO image directly with the **coreos-installer iso customize** subcommand. When you boot the ISO image, the customizations are applied automatically.

You can use this feature to configure the ISO image to automatically install RHCOS.

Procedure

1. Download the **coreos-installer** binary from the **coreos-installer** image mirror page.
2. Retrieve the RHCOS ISO image from the RHCOS image mirror page and the Ignition config file, and then run the following command to inject the Ignition config directly into the ISO image:

```
$ coreos-installer iso customize rhcos-<version>-live.x86_64.iso \
    --dest-ignition bootstrap.ign \ 1
    --dest-device /dev/sda 2
```

1. The Ignition config file that is generated from the **openshift-installer** installation program.
2. When you specify this option, the ISO image automatically runs an installation. Otherwise, the image remains configured for installation, but does not install automatically unless you specify the **coreos.inst.install_dev** kernel argument.

3. Optional: To remove the ISO image customizations and return the image to its pristine state, run:

```
$ coreos-installer iso reset rhcos-<version>-live.x86_64.iso
```

You can now re-customize the live ISO image or use it in its pristine state.

Applying your customizations affects every subsequent boot of RHCOS.

11.2.11.3.3.2.1. Modifying a live install ISO image to use a custom certificate authority

You can provide certificate authority (CA) certificates to Ignition with the **--ignition-ca** flag of the **customize** subcommand. You can use the CA certificates during both the installation boot and when provisioning the installed system.

NOTE

Custom CA certificates affect how Ignition fetches remote resources but they do not affect the certificates installed onto the system.

Procedure

1. Download the **coreos-installer** binary from the **coreos-installer** image mirror page.
2. Retrieve the RHCOS ISO image from the RHCOS image mirror page and run the following command to customize the ISO image for use with a custom CA:

```
$ coreos-installer iso customize rhcos-<version>-live.x86_64.iso --ignition-ca cert.pem
```

IMPORTANT

The **coreos.inst.ignition_url** kernel parameter does not work with the **--ignition-ca** flag. You must use the **--dest-ignition** flag to create a customized image for each cluster.

Applying your custom CA certificate affects every subsequent boot of RHCOS.

11.2.11.3.3.2.2. Modifying a live install ISO image with customized network settings

You can embed a NetworkManager keyfile into the live ISO image and pass it through to the installed system with the **--network-keyfile** flag of the **customize** subcommand.

WARNING

When creating a connection profile, you must use a **.nmconnection** filename extension in the filename of the connection profile. If you do not use a **.nmconnection** filename extension, the cluster will apply the connection profile to the live environment, but it will not apply the configuration when the cluster first boots up the nodes, resulting in a setup that does not work.

Procedure

1. Download the **coreos-installer** binary from the **coreos-installer** image mirror page.

2. Create a connection profile for a bonded interface. For example, create the **bond0.nmconnection** file in your local directory with the following content:

```
[connection]
id=bond0
type=bond
interface-name=bond0
multi-connect=1
permissions=

[ethernet]
mac-address-blacklist=

[bond]
miimon=100
mode=active-backup

[ipv4]
method=auto

[ipv6]
method=auto

[proxy]
```

3. Create a connection profile for a secondary interface to add to the bond. For example, create the **bond0-proxy-em1.nmconnection** file in your local directory with the following content:

```
[connection]
id=em1
type=ethernet
interface-name=em1
master=bond0
multi-connect=1
permissions=
slave-type=bond

[ethernet]
mac-address-blacklist=
```

4. Create a connection profile for a secondary interface to add to the bond. For example, create the **bond0-proxy-em2.nmconnection** file in your local directory with the following content:

```
[connection]
id=em2
type=ethernet
interface-name=em2
master=bond0
multi-connect=1
permissions=
slave-type=bond
```

```
[ethernet]
mac-address-blacklist=
```

5. Retrieve the RHCOS ISO image from the RHCOS image mirror page and run the following command to customize the ISO image with your configured networking:

```
$ coreos-installer iso customize rhcos-<version>-live.x86_64.iso \
    --network-keyfile bond0.nmconnection \
    --network-keyfile bond0-proxy-em1.nmconnection \
    --network-keyfile bond0-proxy-em2.nmconnection
```

Network settings are applied to the live system and are carried over to the destination system.

11.2.11.3.3.3. Customizing a live RHCOS PXE environment

You can customize a live RHCOS PXE environment directly with the **coreos-installer pxe customize** subcommand. When you boot the PXE environment, the customizations are applied automatically.

You can use this feature to configure the PXE environment to automatically install RHCOS.

Procedure

1. Download the **coreos-installer** binary from the **coreos-installer** image mirror page.
2. Retrieve the RHCOS **kernel**, **initramfs** and **rootfs** files from the RHCOS image mirror page and the Ignition config file, and then run the following command to create a new **initramfs** file that contains the customizations from your Ignition config:

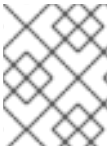
```
$ coreos-installer pxe customize rhcos-<version>-live-initramfs.x86_64.img \
    --dest-ignition bootstrap.ign \ 1
    --dest-device /dev/sda \ 2
    -o rhcos-<version>-custom-initramfs.x86_64.img 3
```

1. The Ignition config file that is generated from **openshift-installer**.
2. When you specify this option, the PXE environment automatically runs an install. Otherwise, the image remains configured for installing, but does not do so automatically unless you specify the **coreos.inst.install_dev** kernel argument.
3. Use the customized **initramfs** file in your PXE configuration. Add the **ignition.firstboot** and **ignition.platform.id=metal** kernel arguments if they are not already present.

Applying your customizations affects every subsequent boot of RHCOS.

11.2.11.3.3.3.1. Modifying a live install PXE environment to use a custom certificate authority

You can provide certificate authority (CA) certificates to Ignition with the **--ignition-ca** flag of the **customize** subcommand. You can use the CA certificates during both the installation boot and when provisioning the installed system.



NOTE

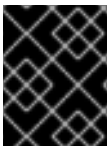
Custom CA certificates affect how Ignition fetches remote resources but they do not affect the certificates installed onto the system.

Procedure

1. Download the **coreos-installer** binary from the **coreos-installer** image mirror page.
2. Retrieve the RHCOS **kernel**, **initramfs** and **rootfs** files from the RHCOS image mirror page and run the following command to create a new customized **initramfs** file for use with a custom CA:

```
$ coreos-installer pxe customize rhcos-<version>-live-initramfs.x86_64.img \
    --ignition-ca cert.pem \
    -o rhcos-<version>-custom-initramfs.x86_64.img
```

3. Use the customized **initramfs** file in your PXE configuration. Add the **ignition.firstboot** and **ignition.platform.id=metal** kernel arguments if they are not already present.



IMPORTANT

The **coreos.inst.ignition_url** kernel parameter does not work with the **--ignition-ca** flag. You must use the **--dest-ignition** flag to create a customized image for each cluster.

Applying your custom CA certificate affects every subsequent boot of RHCOS.

11.2.11.3.3.3.2. Modifying a live install PXE environment with customized network settings

You can embed a NetworkManager keyfile into the live PXE environment and pass it through to the installed system with the **--network-keyfile** flag of the **customize** subcommand.

WARNING

When creating a connection profile, you must use a **.nmconnection** filename extension in the filename of the connection profile. If you do not use a **.nmconnection** filename extension, the cluster will apply the connection profile to the live environment, but it will not apply the configuration when the cluster first boots up the nodes, resulting in a setup that does not work.

Procedure

1. Download the **coreos-installer** binary from the **coreos-installer** image mirror page.
2. Create a connection profile for a bonded interface. For example, create the **bond0.nmconnection** file in your local directory with the following content:

```
[connection]
id=bond0
type=bond
interface-name=bond0
```

```
multi-connect=1
permissions=

[ethernet]
mac-address-blacklist=

[bond]
miimon=100
mode=active-backup

[ipv4]
method=auto

[ipv6]
method=auto

[proxy]
```

3. Create a connection profile for a secondary interface to add to the bond. For example, create the **bond0-proxy-em1.nmconnection** file in your local directory with the following content:

```
[connection]
id=em1
type=ethernet
interface-name=em1
master=bond0
multi-connect=1
permissions=
slave-type=bond

[ethernet]
mac-address-blacklist=
```

4. Create a connection profile for a secondary interface to add to the bond. For example, create the **bond0-proxy-em2.nmconnection** file in your local directory with the following content:

```
[connection]
id=em2
type=ethernet
interface-name=em2
master=bond0
multi-connect=1
permissions=
slave-type=bond

[ethernet]
mac-address-blacklist=
```

5. Retrieve the RHCOS **kernel**, **initramfs** and **rootfs** files from the RHCOS image mirror page and run the following command to create a new customized **initramfs** file that contains your configured networking:

```
$ coreos-installer pxe customize rhcos-<version>-live-initramfs.x86_64.img \
    --network-keyfile bond0.nmconnection \
    --network-keyfile bond0-proxy-em1.nmconnection \
```

```
--network-keyfile bond0-proxy-em2.nmconnection \
-o rhcos-<version>-custom-initramfs.x86_64.img
```

6. Use the customized **initramfs** file in your PXE configuration. Add the **ignition.firstboot** and **ignition.platform.id=metal** kernel arguments if they are not already present.
Network settings are applied to the live system and are carried over to the destination system.

11.2.11.3.4. Advanced RHCOS installation reference

This section illustrates the networking configuration and other advanced options that allow you to modify the Red Hat Enterprise Linux CoreOS (RHCOS) manual installation process. The following tables describe the kernel arguments and command-line options you can use with the RHCOS live installer and the **coreos-installer** command.

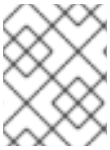
11.2.11.3.4.1. Networking and bonding options for ISO installations

If you install RHCOS from an ISO image, you can add kernel arguments manually when you boot the image to configure networking for a node. If no networking arguments are specified, DHCP is activated in the initramfs when RHCOS detects that networking is required to fetch the Ignition config file.

IMPORTANT

When adding networking arguments manually, you must also add the **rd.neednet=1** kernel argument to bring the network up in the initramfs.

The following information provides examples for configuring networking and bonding on your RHCOS nodes for ISO installations. The examples describe how to use the **ip=**, **nameserver=**, and **bond=** kernel arguments.



NOTE

Ordering is important when adding the kernel arguments: **ip=**, **nameserver=**, and then **bond=**.

The networking options are passed to the **dracut** tool during system boot. For more information about the networking options supported by **dracut**, see the **dracut.cmdline** manual page.

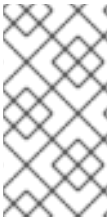
The following examples are the networking options for ISO installation.

Configuring DHCP or static IP addresses
To configure an IP address, either use DHCP (**ip=dhcp**) or set an individual static IP address (**ip=<host_ip>**). If setting a static IP, you must then identify the DNS server IP address (**nameserver=<dns_ip>**) on each node. The following example sets:

- The node's IP address to **10.10.10.2**
- The gateway address to **10.10.10.254**
- The netmask to **255.255.255.0**
- The hostname to **core0.example.com**
- The DNS server address to **4.4.4.41**

- The auto-configuration value to **none**. No auto-configuration is required when IP networking is configured statically.

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp1s0:none
nameserver=4.4.4.41
```



NOTE

When you use DHCP to configure IP addressing for the RHCOS machines, the machines also obtain the DNS server information through DHCP. For DHCP-based deployments, you can define the DNS server address that is used by the RHCOS nodes through your DHCP server configuration.

Configuring an IP address without a static hostname
You can configure an IP address without assigning a static hostname. If a static hostname is not set by the user, it will be picked up and automatically set by a reverse DNS lookup. To configure an IP address without a static hostname refer to the following example:

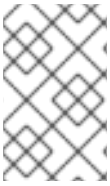
- The node's IP address to **10.10.10.2**
- The gateway address to **10.10.10.254**
- The netmask to **255.255.255.0**
- The DNS server address to **4.4.4.41**
- The auto-configuration value to **none**. No auto-configuration is required when IP networking is configured statically.

```
ip=10.10.10.2::10.10.10.254:255.255.255.0::enp1s0:none
nameserver=4.4.4.41
```

Specifying multiple network interfaces
You can specify multiple network interfaces by setting multiple **ip=** entries.

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp1s0:none
ip=10.10.10.3::10.10.10.254:255.255.255.0:core0.example.com:enp2s0:none
```

Configuring default gateway and route
Optional: You can configure routes to additional networks by setting an **rd.route=** value.



NOTE

When you configure one or multiple networks, one default gateway is required. If the additional network gateway is different from the primary network gateway, the default gateway must be the primary network gateway.

- Run the following command to configure the default gateway:

```
ip=::10.10.10.254::::
```

- Enter the following command to configure the route for the additional network:

```
rd.route=20.20.20.0/24:20.20.20.254:enp2s0
```

Disabling DHCP on a single interface
You can disable DHCP on a single interface, such as when there are two or more network interfaces and only one interface is being used. In the example, the **enp1s0** interface has a static networking configuration and DHCP is disabled for **enp2s0**, which is not used:

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp1s0:none
ip=::::core0.example.com:enp2s0:none
```

Combining DHCP and static IP configurations
You can combine DHCP and static IP configurations on systems with multiple network interfaces, for example:

```
ip=enp1s0:dhcp
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp2s0:none
```

Configuring VLANs on individual interfaces
Optional: You can configure VLANs on individual interfaces by using the **vlan=** parameter.

- To configure a VLAN on a network interface and use a static IP address, run the following command:

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp2s0.100:none
vlan=enp2s0.100:enp2s0
```

- To configure a VLAN on a network interface and to use DHCP, run the following command:

```
ip=enp2s0.100:dhcp
vlan=enp2s0.100:enp2s0
```

Providing multiple DNS servers
You can provide multiple DNS servers by adding a **nameserver=** entry for each server, for example:

```
nameserver=1.1.1.1
nameserver=8.8.8.8
```

Bonding multiple network interfaces to a single interface
Optional: You can bond multiple network interfaces to a single interface by using the **bond=** option. Refer to the following examples:

- The syntax for configuring a bonded interface is: **bond=name[:network_interfaces][:options]** *name* is the bonding device name (**bond0**), *network_interfaces* represents a comma-separated list of physical (ethernet) interfaces (**em1,em2**), and *options* is a comma-separated list of bonding options. Enter **modinfo bonding** to see available options.

- When you create a bonded interface using **bond=**, you must specify how the IP address is assigned and other information for the bonded interface.

- To configure the bonded interface to use DHCP, set the bond's IP address to **dhcp**. For example:

```
bond=bond0:em1,em2:mode=active-backup
ip=bond0:dhcp
```

- To configure the bonded interface to use a static IP address, enter the specific IP address you want and related information. For example:

```
bond=bond0:em1,em2:mode=active-backup
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:bond0:none
```

Bonding multiple network interfaces to a single interface
Optional: You can configure VLANs on bonded interfaces by using the **vlan=** parameter and to use DHCP, for example:

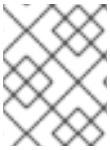
```
ip=bond0.100:dhcp
bond=bond0:em1,em2:mode=active-backup
vlan=bond0.100:bond0
```

Use the following example to configure the bonded interface with a VLAN and to use a static IP address:

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:bond0.100:none
bond=bond0:em1,em2:mode=active-backup
vlan=bond0.100:bond0
```

Using network teaming
Optional: You can use a network teaming as an alternative to bonding by using the **team=** parameter:

- The syntax for configuring a team interface is: **team=name[:network_interfaces]**
  name is the team device name (**team0**) and *network_interfaces* represents a comma-separated list of physical (ethernet) interfaces (**em1, em2**).



NOTE

Teaming is planned to be deprecated when RHCOS switches to an upcoming version of RHEL. For more information, see this Red Hat Knowledgebase Article .

Use the following example to configure a network team:

```
team=team0:em1,em2
ip=team0:dhcp
```

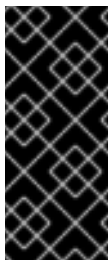
11.2.11.3.4.2. coreos-installer options for ISO and PXE installations

You can install RHCOS by running **coreos-installer install <options> <device>** at the command prompt, after booting into the RHCOS live environment from an ISO image.

The following table shows the subcommands, options, and arguments you can pass to the **coreos-installer** command.

Table 11.12. coreos-installer subcommands, command-line options, and arguments

coreos-installer install subcommand

Subcommand	*Description*
$ coreos-installer install <options> <device>	Embed an Ignition config in an ISO image.
coreos-installer install subcommand options	
Option	*Description*
-u, **--image-url <url>**	Specify the image URL manually.
-f, **--image-file <path>**	Specify a local image file manually. Used for debugging.
-i, --ignition-file <path>	Embed an Ignition config from a file.
-I, **--ignition-url <URL>**	Embed an Ignition config from a URL.
--ignition-hash <digest>	Digest **type-value** of the Ignition config.
-p, **--platform <name>**	Override the Ignition platform ID for the installed system.
--append-karg <arg>…	Append a default kernel argument to the installed system.
--delete-karg <arg>…	Delete a default kernel argument from the installed system.
-n, **--copy-network**	Copy the network configuration from the install environment.  **IMPORTANT** The **--copy-network** option only copies networking configuration found under **/etc/NetworkManager/system-connections**. In particular, it does not copy the system hostname.
--network-dir <path>	For use with **-n**. Default is **/etc/NetworkManager/system-connections/**.
--save-partlabel <lx>..	Save partitions with this label glob.
--save-partindex <id>…	Save partitions with this number or range.
--insecure	Skip RHCOS image signature verification.

--insecure-ignition	Allow Ignition URL without HTTPS or hash.
--architecture <name>	Target CPU architecture. Valid values are **x86_64** and **aarch64**.
--preserve-on-error	Do not clear partition table on error.
-h, **--help**	Print help information.
coreos-installer install subcommand argument	
Argument	*Description*
<device>	The destination device.
coreos-installer ISO subcommands	
Subcommand	*Description*
$ coreos-installer iso customize <options> <ISO_image>	Customize a RHCOS live ISO image.
coreos-installer iso reset <options> <ISO_image>	Restore a RHCOS live ISO image to default settings.
coreos-installer iso ignition remove <options> <ISO_image>	Remove the embedded Ignition config from an ISO image.
coreos-installer ISO customize subcommand options	
Option	*Description*
--dest-ignition <path>	Merge the specified Ignition config file into a new configuration fragment for the destination system.
--dest-device <path>	Install and overwrite the specified destination device.
--dest-karg-append <arg>	Add a kernel argument to each boot of the destination system.
--dest-karg-delete <arg>	Delete a kernel argument from each boot of the destination system.
--network-keyfile <path>	Configure networking by using the specified NetworkManager keyfile for live and destination systems.

--ignition-ca <path>	Specify an additional TLS certificate authority to be trusted by Ignition.
--pre-install <path>	Run the specified script before installation.
--post-install <path>	Run the specified script after installation.
--installer-config <path>	Apply the specified installer configuration file.
--live-ignition <path>	Merge the specified Ignition config file into a new configuration fragment for the live environment.
--live-karg-append <arg>	Add a kernel argument to each boot of the live environment.
--live-karg-delete <arg>	Delete a kernel argument from each boot of the live environment.
--live-karg-replace <k=o=n>	Replace a kernel argument in each boot of the live environment, in the form **key=old=new**.
-f, **--force**	Overwrite an existing Ignition config.
-o, **--output <path>**	Write the ISO to a new output file.
-h, **--help**	Print help information.
coreos-installer PXE subcommands	
Subcommand	*Description*
Note that not all of these options are accepted by all subcommands.	
coreos-installer pxe customize <options> <path>	Customize a RHCOS live PXE boot config.
coreos-installer pxe ignition wrap <options>	Wrap an Ignition config in an image.
coreos-installer pxe ignition unwrap <options> <image_name>	Show the wrapped Ignition config in an image.
coreos-installer PXE customize subcommand options	
Option	*Description*
Note that not all of these options are accepted by all subcommands.	

--dest-ignition <path>	Merge the specified Ignition config file into a new configuration fragment for the destination system.
--dest-device <path>	Install and overwrite the specified destination device.
--network-keyfile <path>	Configure networking by using the specified NetworkManager keyfile for live and destination systems.
--ignition-ca <path>	Specify an additional TLS certificate authority to be trusted by Ignition.
--pre-install <path>	Run the specified script before installation.
post-install <path>	Run the specified script after installation.
--installer-config <path>	Apply the specified installer configuration file.
--live-ignition <path>	Merge the specified Ignition config file into a new configuration fragment for the live environment.
-o, --output <path>	Write the initramfs to a new output file. NOTE This option is required for PXE environments.
-h, --help	Print help information.

11.2.11.3.4.3. coreos.inst boot options for ISO or PXE installations

You can automatically invoke **coreos-installer** options at boot time by passing **coreos.inst** boot arguments to the RHCOS live installer. These are provided in addition to the standard boot arguments.

- For ISO installations, the **coreos.inst** options can be added by interrupting the automatic boot at the bootloader menu. You can interrupt the automatic boot by pressing **TAB** while the **RHEL CoreOS (Live)** menu option is highlighted.
- For PXE or iPXE installations, the **coreos.inst** options must be added to the **APPEND** line before the RHCOS live installer is booted.

The following table shows the RHCOS live installer **coreos.inst** boot options for ISO and PXE installations.

Table 11.13. coreos.inst boot options

Argument	Description
coreos.inst.install_dev	Required. The block device on the system to install to. It is recommended to use the full path, such as **/dev/sda**, although **sda** is allowed.
coreos.inst.ignition_url	Optional: The URL of the Ignition config to embed into the installed system. If no URL is specified, no Ignition config is embedded. Only HTTP and HTTPS protocols are supported.
coreos.inst.save_partlabel	Optional: Comma-separated labels of partitions to preserve during the install. Glob-style wildcards are permitted. The specified partitions do not need to exist.
coreos.inst.save_partindex	Optional: Comma-separated indexes of partitions to preserve during the install. Ranges **m-n** are permitted, and either **m** or **n** can be omitted. The specified partitions do not need to exist.
coreos.inst.insecure	Optional: Permits the OS image that is specified by **coreos.inst.image_url** to be unsigned.
coreos.inst.image_url	Optional: Download and install the specified RHCOS image. • This argument should not be used in production environments and is intended for debugging purposes only. • While this argument can be used to install a version of RHCOS that does not match the live media, it is recommended that you instead use the media that matches the version you want to install. • If you are using **coreos.inst.image_url**, you must also use **coreos.inst.insecure**. This is because the bare-metal media are not GPG-signed for OpenShift Container Platform. • Only HTTP and HTTPS protocols are supported.
coreos.inst.skip_reboot	Optional: The system will not reboot after installing. After the install finishes, you will receive a prompt that allows you to inspect what is happening during installation. This argument should not be used in production environments and is intended for debugging purposes only.

Argument	Description
coreos.inst.platform_id	Optional: The Ignition platform ID of the platform the RHCOS image is being installed on. Default is **metal**. This option determines whether or not to request an Ignition config from the cloud provider, such as VMware. For example: **coreos.inst.platform_id=vmware**.
ignition.config.url	Optional: The URL of the Ignition config for the live boot. For example, this can be used to customize how **coreos-installer** is invoked, or to run code before or after the installation. This is different from **coreos.inst.ignition_url**, which is the Ignition config for the installed system.

11.2.11.4. Enabling multipathing with kernel arguments on RHCOS

RHCOS supports multipathing on the primary disk, allowing stronger resilience to hardware failure to achieve higher host availability.

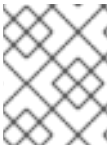
You can enable multipathing at installation time for nodes that were provisioned in OpenShift Container Platform 4.8 or later. While postinstallation support is available by activating multipathing via the machine config, enabling multipathing during installation is recommended.

In setups where any I/O to non-optimized paths results in I/O system errors, you must enable multipathing at installation time.

IMPORTANT

On IBM Z and LinuxONE, you can enable multipathing only if you configured your cluster for it during installation. For more information, see "Installing RHCOS and starting the OpenShift Container Platform bootstrap process" in *Installing a cluster with z/VM on IBM Z and LinuxONE*.

The following procedure enables multipath at installation time and appends kernel arguments to the **coreos-installer install** command so that the installed system itself will use multipath beginning from the first boot.



NOTE

OpenShift Container Platform does not support enabling multipathing as a day-2 activity on nodes that have been upgraded from 4.6 or earlier.

Procedure

1. To enable multipath and start the **multipathd** daemon, run the following command:

```
$ mpathconf --enable && systemctl start multipathd.service
```

- Optional: If booting the PXE or ISO, you can instead enable multipath by adding **rd.multipath=default** from the kernel command line.

2. Append the kernel arguments by invoking the **coreos-installer** program:

   - If there is only one multipath device connected to the machine, it should be available at path **/dev/mapper/mpatha**. For example:

     ```
     $ coreos-installer install /dev/mapper/mpatha \ 1
     --append-karg rd.multipath=default \
     --append-karg root=/dev/disk/by-label/dm-mpath-root \
     --append-karg rw
     ```

     1 Indicates the path of the single multipathed device.

   - If there are multiple multipath devices connected to the machine, or to be more explicit, instead of using **/dev/mapper/mpatha**, it is recommended to use the World Wide Name (WWN) symlink available in **/dev/disk/by-id**. For example:

     ```
     $ coreos-installer install /dev/disk/by-id/wwn-<wwn_ID> \ 1
     --append-karg rd.multipath=default \
     --append-karg root=/dev/disk/by-label/dm-mpath-root \
     --append-karg rw
     ```

     1 Indicates the WWN ID of the target multipathed device. For example, **0xx194e957fcedb4841**.

     This symlink can also be used as the **coreos.inst.install_dev** kernel argument when using special **coreos.inst.*** arguments to direct the live installer. For more information, see "Installing RHCOS and starting the OpenShift Container Platform bootstrap process".

3. Check that the kernel arguments worked by going to one of the worker nodes and listing the kernel command line arguments (in **/proc/cmdline** on the host):

   ```
   $ oc debug node/ip-10-0-141-105.ec2.internal
   ```

   Example output

   ```
   Starting pod/ip-10-0-141-105ec2internal-debug ...
   To use host binaries, run `chroot /host`

   sh-4.2# cat /host/proc/cmdline
   ...
   rd.multipath=default root=/dev/disk/by-label/dm-mpath-root
   ...

   sh-4.2# exit
   ```

   You should see the added kernel arguments.

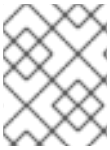
Additional resources

- See Installing RHCOS and starting the OpenShift Container Platform bootstrap process for more information on using special **coreos.inst.*** arguments to direct the live installer.

11.2.11.5. Updating the bootloader using bootupd

To update the bootloader by using **bootupd**, you must either install **bootupd** on RHCOS machines manually or provide a machine config with the enabled **systemd** unit. Unlike **grubby** or other bootloader tools, **bootupd** does not manage kernel space configuration such as passing kernel arguments.

After you have installed **bootupd**, you can manage it remotely from the OpenShift Container Platform cluster.



NOTE

It is recommended that you use **bootupd** only on bare metal or virtualized hypervisor installations, such as for protection against the BootHole vulnerability.

Manual install method

You can manually install **bootupd** by using the **bootctl** command-line tool.

1. Inspect the system status:

```
# bootupctl status
```

Example output for x86_64

```
Component EFI
  Installed: grub2-efi-x64-1:2.04-31.fc33.x86_64,shim-x64-15-8.x86_64
  Update: At latest version
```

Example output for aarch64

```
Component EFI
  Installed: grub2-efi-aa64-1:2.02-99.el8_4.1.aarch64,shim-aa64-15.4-2.el8_1.aarch64
  Update: At latest version
```

2. RHCOS images created without **bootupd** installed on them require an explicit adoption phase. If the system status is **Adoptable**, perform the adoption:

```
# bootupctl adopt-and-update
```

Example output

```
Updated: grub2-efi-x64-1:2.04-31.fc33.x86_64,shim-x64-15-8.x86_64
```

3. If an update is available, apply the update so that the changes take effect on the next reboot:

```
# bootupctl update
```

Example output

```
Updated: grub2-efi-x64-1:2.04-31.fc33.x86_64,shim-x64-15-8.x86_64
```

Machine config method

Another way to enable **bootupd** is by providing a machine config.

- Provide a machine config file with the enabled **systemd** unit, as shown in the following example:

  Example output

```
variant: rhcos
version: 1.1.0
systemd:
  units:
    - name: custom-bootupd-auto.service
      enabled: true
      contents: |
        [Unit]
        Description=Bootupd automatic update

        [Service]
        ExecStart=/usr/bin/bootupctl update
        RemainAfterExit=yes

        [Install]
        WantedBy=multi-user.target
```

11.2.12. Waiting for the bootstrap process to complete

The OpenShift Container Platform bootstrap process begins after the cluster nodes first boot into the persistent RHCOS environment that has been installed to disk. The configuration information provided through the Ignition config files is used to initialize the bootstrap process and install OpenShift Container Platform on the machines. You must wait for the bootstrap process to complete.

Prerequisites

- You have created the Ignition config files for your cluster.
- You have configured suitable network, DNS and load balancing infrastructure.
- You have obtained the installation program and generated the Ignition config files for your cluster.
- You installed RHCOS on your cluster machines and provided the Ignition config files that the OpenShift Container Platform installation program generated.
- Your machines have direct internet access or have an HTTP or HTTPS proxy available.

Procedure

1. Monitor the bootstrap process:

```
$ ./openshift-install --dir <installation_directory> wait-for bootstrap-complete \ 1
    --log-level=info 2
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

Example output

```
INFO Waiting up to 30m0s for the Kubernetes API at https://api.test.example.com:6443...
INFO API v1.24.0 up
INFO Waiting up to 30m0s for bootstrapping to complete...
INFO It is now safe to remove the bootstrap resources
```

The command succeeds when the Kubernetes API server signals that it has been bootstrapped on the control plane machines.

2. After the bootstrap process is complete, remove the bootstrap machine from the load balancer.

IMPORTANT

You must remove the bootstrap machine from the load balancer at this point. You can also remove or reformat the bootstrap machine itself.

Additional resources

- See Monitoring installation progress for more information about monitoring the installation logs and retrieving diagnostic data if installation issues arise.

11.2.13. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

Example output

```
system:admin
```

11.2.14. Approving the certificate signing requests for your machines

When you add machines to a cluster, two pending certificate signing requests (CSRs) are generated for each machine that you added. You must confirm that these CSRs are approved or, if necessary, approve them yourself. The client requests must be approved first, followed by the server requests.

Prerequisites

- You added machines to your cluster.

Procedure

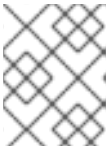
1. Confirm that the cluster recognizes the machines:

```
$ oc get nodes
```

Example output

```
NAME      STATUS    ROLES   AGE  VERSION
master-0  Ready     master  63m  v1.24.0
master-1  Ready     master  63m  v1.24.0
master-2  Ready     master  64m  v1.24.0
```

The output lists all of the machines that you created.



NOTE

The preceding output might not include the compute nodes, also known as worker nodes, until some CSRs are approved.

2. Review the pending CSRs and ensure that you see the client requests with the **Pending** or **Approved** status for each machine that you added to the cluster:

```
$ oc get csr
```

Example output

```
NAME        AGE     REQUESTOR                                                   CONDITION
csr-8b2br   15m     system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper   Pending
csr-8vnps   15m     system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper   Pending
...
```

In this example, two machines are joining the cluster. You might see more approved CSRs in the list.

3. If the CSRs were not approved, after all of the pending CSRs for the machines you added are in **Pending** status, approve the CSRs for your cluster machines:

NOTE

Because the CSRs rotate automatically, approve your CSRs within an hour of adding the machines to the cluster. If you do not approve them within an hour, the certificates will rotate, and more than two certificates will be present for each node. You must approve all of these certificates. After the client CSR is approved, the Kubelet creates a secondary CSR for the serving certificate, which requires manual approval. Then, subsequent serving certificate renewal requests are automatically approved by the **machine-approver** if the Kubelet requests a new certificate with identical parameters.

NOTE

For clusters running on platforms that are not machine API enabled, such as bare metal and other user-provisioned infrastructure, you must implement a method of automatically approving the kubelet serving certificate requests (CSRs). If a request is not approved, then the **oc exec**, **oc rsh**, and **oc logs** commands cannot succeed, because a serving certificate is required when the API server connects to the kubelet. Any operation that contacts the Kubelet endpoint requires this certificate approval to be in place. The method must watch for new CSRs, confirm that the CSR was submitted by the **node-bootstrapper** service account in the **system:node** or **system:admin** groups, and confirm the identity of the node.

- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

1 **<csr_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{{"\n"}}
{{end}}{{end}}' | xargs --no-run-if-empty oc adm certificate approve
```

NOTE

Some Operators might not become available until some CSRs are approved.

4. Now that your client requests are approved, you must review the server requests for each machine that you added to the cluster:

```
$ oc get csr
```

Example output

```
NAME        AGE    REQUESTOR                                                   CONDITION
csr-bfd72   5m26s  system:node:ip-10-0-50-126.us-east-2.compute.internal
Pending
```

```
csr-c57lv   5m26s   system:node:ip-10-0-95-157.us-east-2.compute.internal
Pending
...
```

5. If the remaining CSRs are not approved, and are in the **Pending** status, approve the CSRs for your cluster machines:

   - To approve them individually, run the following command for each valid CSR:

     ```
     $ oc adm certificate approve <csr_name> 1
     ```

     1 **<csr_name>** is the name of a CSR from the list of current CSRs.

   - To approve all pending CSRs, run the following command:

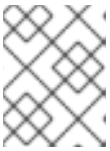
     ```
     $ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{{"\n"}}
     {{end}}{{end}}' | xargs oc adm certificate approve
     ```

6. After all client and server CSRs have been approved, the machines have the **Ready** status. Verify this by running the following command:

   ```
   $ oc get nodes
   ```

   Example output

   ```
   NAME      STATUS    ROLES   AGE  VERSION
   master-0  Ready     master  73m  v1.24.0
   master-1  Ready     master  73m  v1.24.0
   master-2  Ready     master  74m  v1.24.0
   worker-0  Ready     worker  11m  v1.24.0
   worker-1  Ready     worker  11m  v1.24.0
   ```



NOTE

It can take a few minutes after approval of the server CSRs for the machines to transition to the **Ready** status.

Additional information

- For more information on CSRs, see Certificate Signing Requests.

11.2.15. Initial Operator configuration

After the control plane initializes, you must immediately configure some Operators so that they all become available.

Prerequisites

- Your control plane has initialized.

Procedure

1. Watch the cluster components come online:

```
$ watch -n5 oc get clusteroperators
```

Example output

```
NAME                                       VERSION   AVAILABLE   PROGRESSING   DEGRADED
SINCE
authentication                             4.11.0    True        False         False      19m
baremetal                                  4.11.0    True        False         False      37m
cloud-credential                           4.11.0    True        False         False      40m
cluster-autoscaler                         4.11.0    True        False         False      37m
config-operator                            4.11.0    True        False         False      38m
console                                    4.11.0    True        False         False      26m
csi-snapshot-controller                    4.11.0    True        False         False      37m
dns                                        4.11.0    True        False         False      37m
etcd                                       4.11.0    True        False         False      36m
image-registry                             4.11.0    True        False         False      31m
ingress                                    4.11.0    True        False         False      30m
insights                                   4.11.0    True        False         False      31m
kube-apiserver                             4.11.0    True        False         False      26m
kube-controller-manager                    4.11.0    True        False         False      36m
kube-scheduler                             4.11.0    True        False         False      36m
kube-storage-version-migrator              4.11.0    True        False         False      37m
machine-api                                4.11.0    True        False         False      29m
machine-approver                           4.11.0    True        False         False      37m
machine-config                             4.11.0    True        False         False      36m
marketplace                                4.11.0    True        False         False      37m
monitoring                                 4.11.0    True        False         False      29m
network                                    4.11.0    True        False         False      38m
node-tuning                                4.11.0    True        False         False      37m
openshift-apiserver                        4.11.0    True        False         False      32m
openshift-controller-manager               4.11.0    True        False         False      30m
openshift-samples                          4.11.0    True        False         False      32m
operator-lifecycle-manager                 4.11.0    True        False         False      37m
operator-lifecycle-manager-catalog         4.11.0    True        False         False      37m
operator-lifecycle-manager-packageserver   4.11.0    True        False         False      32m
service-ca                                 4.11.0    True        False         False      38m
storage                                    4.11.0    True        False         False      37m
```

2. Configure the Operators that are not available.

Additional resources

- See Gathering logs from a failed installation for details about gathering data in the event of a failed OpenShift Container Platform installation.
- See Troubleshooting Operator issues for steps to check Operator pod health across the cluster and gather Operator logs for diagnosis.

11.2.15.1. Image registry removed during installation

On platforms that do not provide shareable object storage, the OpenShift Image Registry Operator bootstraps itself as **Removed**. This allows **openshift-installer** to complete installations on these platform types.

After installation, you must edit the Image Registry Operator configuration to switch the **managementState** from **Removed** to **Managed**.

11.2.15.2. Image registry storage configuration

The Image Registry Operator is not initially available for platforms that do not provide default storage. After installation, you must configure your registry to use storage so that the Registry Operator is made available.

Instructions are shown for configuring a persistent volume, which is required for production clusters. Where applicable, instructions are shown for configuring an empty directory as the storage location, which is available for only non-production clusters.

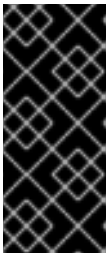
Additional instructions are provided for allowing the image registry to use block storage types by using the **Recreate** rollout strategy during upgrades.

11.2.15.2.1. Configuring registry storage for bare metal and other manual installations

As a cluster administrator, following installation you must configure your registry to use storage.

Prerequisites

- You have access to the cluster as a user with the **cluster-admin** role.
- You have a cluster that uses manually-provisioned Red Hat Enterprise Linux CoreOS (RHCOS) nodes, such as bare metal.
- You have provisioned persistent storage for your cluster, such as Red Hat OpenShift Data Foundation.



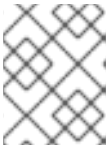
IMPORTANT

OpenShift Container Platform supports **ReadWriteOnce** access for image registry storage when you have only one replica. **ReadWriteOnce** access also requires that the registry uses the **Recreate** rollout strategy. To deploy an image registry that supports high availability with two or more replicas, **ReadWriteMany** access is required.

- Must have 100Gi capacity.

Procedure

1. To configure your registry to use storage, change the **spec.storage.pvc** in the **configs.imageregistry/cluster** resource.



NOTE

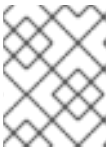
When you use shared storage, review your security settings to prevent outside access.

2. Verify that you do not have a registry pod:

```
$ oc get pod -n openshift-image-registry -l docker-registry=default
```

Example output

```
No resourses found in openshift-image-registry namespace
```



NOTE

If you do have a registry pod in your output, you do not need to continue with this procedure.

3. Check the registry configuration:

```
$ oc edit configs.imageregistry.operator.openshift.io
```

Example output

```
storage:
  pvc:
    claim:
```

Leave the **claim** field blank to allow the automatic creation of an **image-registry-storage** PVC.

4. Check the **clusteroperator** status:

```
$ oc get clusteroperator image-registry
```

Example output

```
NAME            VERSION          AVAILABLE   PROGRESSING   DEGRADED   SINCE
MESSAGE
image-registry   4.11             True        False         False      6h50m
```

5. Ensure that your registry is set to managed to enable building and pushing of images.

- Run:

```
$ oc edit configs.imageregistry/cluster
```

Then, change the line

```
managementState: Removed
```

to

```
managementState: Managed
```

11.2.15.2.2. Configuring storage for the image registry in non-production clusters

You must configure storage for the Image Registry Operator. For non-production clusters, you can set the image registry to an empty directory. If you do so, all images are lost if you restart the registry.

Procedure

- To set the image registry storage to an empty directory:

```
$ oc patch configs.imageregistry.operator.openshift.io cluster --type merge --patch '{"spec":{"storage":{"emptyDir":{}}}}'
```

WARNING

Configure this option for only non-production clusters.

If you run this command before the Image Registry Operator initializes its components, the **oc patch** command fails with the following error:

```
Error from server (NotFound): configs.imageregistry.operator.openshift.io "cluster" not found
```

Wait a few minutes and run the command again.

11.2.15.2.3. Configuring block registry storage for bare metal

To allow the image registry to use block storage types during upgrades as a cluster administrator, you can use the **Recreate** rollout strategy.

IMPORTANT

Block storage volumes, or block persistent volumes, are supported but not recommended for use with the image registry on production clusters. An installation where the registry is configured on block storage is not highly available because the registry cannot have more than one replica.

If you choose to use a block storage volume with the image registry, you must use a filesystem persistent volume claim (PVC).

Procedure

1. Enter the following command to set the image registry storage as a block storage type, patch the registry so that it uses the **Recreate** rollout strategy, and runs with only one (**1**) replica:

```
$ oc patch config.imageregistry.operator.openshift.io/cluster --type=merge -p '{"spec":{"rolloutStrategy":"Recreate","replicas":1}}'
```

2. Provision the PV for the block storage device, and create a PVC for that volume. The requested block volume uses the ReadWriteOnce (RWO) access mode.

   a. Create a **pvc.yaml** file with the following contents to define a VMware vSphere **PersistentVolumeClaim** object:

```
kind: PersistentVolumeClaim
apiVersion: v1
metadata:
  name: image-registry-storage 1
```

```
  namespace: openshift-image-registry 2
spec:
  accessModes:
  - ReadWriteOnce 3
  resources:
    requests:
      storage: 100Gi 4
```

1. A unique name that represents the **PersistentVolumeClaim** object.
2. The namespace for the **PersistentVolumeClaim** object, which is **openshift-image-registry**.
3. The access mode of the persistent volume claim. With **ReadWriteOnce**, the volume can be mounted with read and write permissions by a single node.
4. The size of the persistent volume claim.

b. Enter the following command to create the **PersistentVolumeClaim** object from the file:

```
$ oc create -f pvc.yaml -n openshift-image-registry
```

3. Enter the following command to edit the registry configuration so that it references the correct PVC:

```
$ oc edit config.imageregistry.operator.openshift.io -o yaml
```

Example output

```
storage:
  pvc:
    claim: 1
```

1. By creating a custom PVC, you can leave the **claim** field blank for the default automatic creation of an **image-registry-storage** PVC.

11.2.16. Completing installation on user-provisioned infrastructure

After you complete the Operator configuration, you can finish installing the cluster on infrastructure that you provide.

Prerequisites

- Your control plane has initialized.
- You have completed the initial Operator configuration.

Procedure

1. Confirm that all the cluster components are online with the following command:

```
$ watch -n5 oc get clusteroperators
```

-

Example output

```
NAME                                       VERSION   AVAILABLE   PROGRESSING   DEGRADED
SINCE
authentication                             4.11.0    True        False         False      19m
baremetal                                  4.11.0    True        False         False      37m
cloud-credential                           4.11.0    True        False         False      40m
cluster-autoscaler                         4.11.0    True        False         False      37m
config-operator                            4.11.0    True        False         False      38m
console                                    4.11.0    True        False         False      26m
csi-snapshot-controller                    4.11.0    True        False         False      37m
dns                                        4.11.0    True        False         False      37m
etcd                                       4.11.0    True        False         False      36m
image-registry                             4.11.0    True        False         False      31m
ingress                                    4.11.0    True        False         False      30m
insights                                   4.11.0    True        False         False      31m
kube-apiserver                             4.11.0    True        False         False      26m
kube-controller-manager                    4.11.0    True        False         False      36m
kube-scheduler                             4.11.0    True        False         False      36m
kube-storage-version-migrator              4.11.0    True        False         False      37m
machine-api                                4.11.0    True        False         False      29m
machine-approver                           4.11.0    True        False         False      37m
machine-config                             4.11.0    True        False         False      36m
marketplace                                4.11.0    True        False         False      37m
monitoring                                 4.11.0    True        False         False      29m
network                                    4.11.0    True        False         False      38m
node-tuning                                4.11.0    True        False         False      37m
openshift-apiserver                        4.11.0    True        False         False      32m
openshift-controller-manager               4.11.0    True        False         False      30m
openshift-samples                          4.11.0    True        False         False      32m
operator-lifecycle-manager                 4.11.0    True        False         False      37m
operator-lifecycle-manager-catalog         4.11.0    True        False         False      37m
operator-lifecycle-manager-packageserver   4.11.0    True        False         False      32m
service-ca                                 4.11.0    True        False         False      38m
storage                                    4.11.0    True        False         False      37m
```

Alternatively, the following command notifies you when all of the clusters are available. It also retrieves and displays credentials:

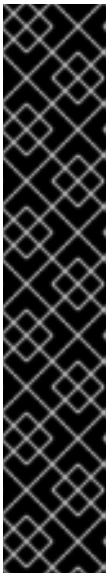
```
$ ./openshift-install --dir <installation_directory> wait-for install-complete 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

Example output

```
INFO Waiting up to 30m0s for the cluster to initialize...
```

The command succeeds when the Cluster Version Operator finishes deploying the OpenShift Container Platform cluster from Kubernetes API server.



IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

2. Confirm that the Kubernetes API server is communicating with the pods.

   a. To view a list of all pods, use the following command:

   ```
   $ oc get pods --all-namespaces
   ```

   Example output

   ```
   NAMESPACE                       NAME                                        READY   STATUS
   RESTARTS   AGE
   openshift-apiserver-operator    openshift-apiserver-operator-85cb746d55-zqhs8   1/1
   Running    1          9m
   openshift-apiserver             apiserver-67b9g                               1/1     Running     0
   3m
   openshift-apiserver             apiserver-ljcmx                               1/1     Running     0
   1m
   openshift-apiserver             apiserver-z25h4                               1/1     Running     0
   2m
   openshift-authentication-operator authentication-operator-69d5d8bf84-vh2n8        1/1
   Running    0          5m
   ...
   ```

   b. View the logs for a pod that is listed in the output of the previous command by using the following command:

   ```
   $ oc logs <pod_name> -n <namespace> 1
   ```

   1 Specify the pod name and namespace, as shown in the output of the previous command.

   If the pod logs display, the Kubernetes API server can communicate with the cluster machines.

3. For an installation with Fibre Channel Protocol (FCP), additional steps are required to enable multipathing. Do not enable multipathing during installation.
   See "Enabling multipathing with kernel arguments on RHCOS" in the *Post-installation machine configuration tasks* documentation for more information.

11.2.17. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.11, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to OpenShift Cluster Manager Hybrid Cloud Console.

After you confirm that your OpenShift Cluster Manager Hybrid Cloud Console inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, use subscription watch to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

Additional resources

- See About remote health monitoring for more information about the Telemetry service

11.2.18. Next steps

- Validating an installation.
- Customize your cluster.
- If necessary, you can opt out of remote health reporting .
- Set up your registry and configure registry storage .

11.3. INSTALLING A USER-PROVISIONED BARE METAL CLUSTER WITH NETWORK CUSTOMIZATIONS

In OpenShift Container Platform 4.11, you can install a cluster on bare metal infrastructure that you provision with customized network configuration options. By customizing your network configuration, your cluster can coexist with existing IP address allocations in your environment and integrate with existing MTU and VXLAN configurations.

When you customize OpenShift Container Platform networking, you must set most of the network configuration parameters during installation. You can modify only **kubeProxy** network configuration parameters in a running cluster.

11.3.1. Prerequisites

- You reviewed details about the OpenShift Container Platform installation and update processes.
- You read the documentation on selecting a cluster installation method and preparing it for users.
- If you use a firewall and plan to use the Telemetry service, you configured the firewall to allow the sites that your cluster requires access to.

11.3.2. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.11, you require access to the internet to install your cluster.

You must have internet access to:

- Access OpenShift Cluster Manager Hybrid Cloud Console to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access Quay.io to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.

IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

Additional resources

- See Installing a user-provisioned bare metal cluster on a restricted network for more information about performing a restricted network installation on bare metal infrastructure that you provision.

11.3.3. Requirements for a cluster with user-provisioned infrastructure

For a cluster that contains user-provisioned infrastructure, you must deploy all of the required machines.

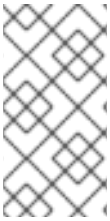
This section describes the requirements for deploying OpenShift Container Platform on user-provisioned infrastructure.

11.3.3.1. Required machines for cluster installation

The smallest OpenShift Container Platform clusters require the following hosts:

Table 11.14. Minimum required hosts

Hosts	Description
One temporary bootstrap machine	The cluster requires the bootstrap machine to deploy the OpenShift Container Platform cluster on the three control plane machines. You can remove the bootstrap machine after you install the cluster.
Three control plane machines	The control plane machines run the Kubernetes and OpenShift Container Platform services that form the control plane.
At least two compute machines, which are also known as worker machines.	The workloads requested by OpenShift Container Platform users run on the compute machines.



NOTE

As an exception, you can run zero compute machines in a bare metal cluster that consists of three control plane machines only. This provides smaller, more resource efficient clusters for cluster administrators and developers to use for testing, development, and production. Running one compute machine is not supported.

IMPORTANT

To maintain high availability of your cluster, use separate physical hosts for these cluster machines.

The bootstrap and control plane machines must use Red Hat Enterprise Linux CoreOS (RHCOS) as the operating system. However, the compute machines can choose between Red Hat Enterprise Linux CoreOS (RHCOS), Red Hat Enterprise Linux (RHEL) 8.6 and later.

Note that RHCOS is based on Red Hat Enterprise Linux (RHEL) 8 and inherits all of its hardware certifications and requirements. See Red Hat Enterprise Linux technology capabilities and limits .

11.3.3.2. Minimum resource requirements for cluster installation

Each cluster machine must meet the following minimum requirements:

Table 11.15. Minimum resource requirements

Machine	Operating System	CPU [1]	RAM	Storage	IOPS [2]
Bootstrap	RHCOS	4	16 GB	100 GB	300
Control plane	RHCOS	4	16 GB	100 GB	300
Compute	RHCOS, RHEL 8.6 and later [3]	2	8 GB	100 GB	300

1. One CPU is equivalent to one physical core when simultaneous multithreading (SMT), or hyperthreading, is not enabled. When enabled, use the following formula to calculate the corresponding ratio: (threads per core × cores) × sockets = CPUs.

2. OpenShift Container Platform and Kubernetes are sensitive to disk performance, and faster storage is recommended, particularly for etcd on the control plane nodes which require a 10 ms p99 fsync duration. Note that on many cloud platforms, storage size and IOPS scale together, so you might need to over-allocate storage volume to obtain sufficient performance.

3. As with all user-provisioned installations, if you choose to use RHEL compute machines in your cluster, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks. Use of RHEL 7 compute machines is deprecated and has been removed in OpenShift Container Platform 4.10 and later.

If an instance type for your platform meets the minimum requirements for cluster machines, it is supported to use in OpenShift Container Platform.

Additional resources

- Optimizing storage

11.3.3.3. Certificate signing requests management

Because your cluster has limited access to automatic machine management when you use infrastructure that you provision, you must provide a mechanism for approving cluster certificate signing requests (CSRs) after installation. The **kube-controller-manager** only approves the kubelet client CSRs. The **machine-approver** cannot guarantee the validity of a serving certificate that is requested by using kubelet credentials because it cannot confirm that the correct machine issued the request. You must determine and implement a method of verifying the validity of the kubelet serving certificate requests and approving them.

Additional resources

- See Configuring a three-node cluster for details about deploying three-node clusters in bare metal environments.
- See Approving the certificate signing requests for your machines for more information about approving cluster certificate signing requests after installation.

11.3.3.4. Networking requirements for user-provisioned infrastructure

All the Red Hat Enterprise Linux CoreOS (RHCOS) machines require networking to be configured in **initramfs** during boot to fetch their Ignition config files.

During the initial boot, the machines require an IP address configuration that is set either through a DHCP server or statically by providing the required boot options. After a network connection is established, the machines download their Ignition config files from an HTTP or HTTPS server. The Ignition config files are then used to set the exact state of each machine. The Machine Config Operator completes more changes to the machines, such as the application of new certificates or keys, after installation.

It is recommended to use a DHCP server for long-term management of the cluster machines. Ensure that the DHCP server is configured to provide persistent IP addresses, DNS server information, and hostnames to the cluster machines.

NOTE

If a DHCP service is not available for your user-provisioned infrastructure, you can instead provide the IP networking configuration and the address of the DNS server to the nodes at RHCOS install time. These can be passed as boot arguments if you are installing from an ISO image. See the *Installing RHCOS and starting the OpenShift Container Platform bootstrap process* section for more information about static IP provisioning and advanced networking options.

The Kubernetes API server must be able to resolve the node names of the cluster machines. If the API servers and worker nodes are in different zones, you can configure a default DNS search zone to allow the API server to resolve the node names. Another supported approach is to always refer to hosts by their fully-qualified domain names in both the node objects and all DNS requests.

11.3.3.4.1. Setting the cluster node hostnames through DHCP

On Red Hat Enterprise Linux CoreOS (RHCOS) machines, the hostname is set through

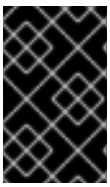
NetworkManager. By default, the machines obtain their hostname through DHCP. If the hostname is not provided by DHCP, set statically through kernel arguments, or another method, it is obtained through a reverse DNS lookup. Reverse DNS lookup occurs after the network has been initialized on a node and can take time to resolve. Other system services can start prior to this and detect the hostname as **localhost** or similar. You can avoid this by using DHCP to provide the hostname for each cluster node.

Additionally, setting the hostnames through DHCP can bypass any manual DNS record name configuration errors in environments that have a DNS split-horizon implementation.

11.3.3.4.2. Network connectivity requirements

You must configure the network connectivity between machines to allow OpenShift Container Platform cluster components to communicate. Each machine must be able to resolve the hostnames of all other machines in the cluster.

This section provides details about the ports that are required.



IMPORTANT

In connected OpenShift Container Platform environments, all nodes are required to have internet access to pull images for platform containers and provide telemetry data to Red Hat.

Table 11.16. Ports used for all-machine to all-machine communications

Protocol	Port	Description
ICMP	N/A	Network reachability tests
TCP	**1936**	Metrics
	9000-**9999**	Host level services, including the node exporter on ports **9100**-**9101** and the Cluster Version Operator on port**9099**.
	10250-**10259**	The default ports that Kubernetes reserves
	10256	openshift-sdn
UDP	**4789**	VXLAN
	6081	Geneve
	9000-**9999**	Host level services, including the node exporter on ports **9100**-**9101**.
	500	IPsec IKE packets
	4500	IPsec NAT-T packets
TCP/UDP	**30000**-**32767**	Kubernetes node port

Protocol	Port	Description
ESP	N/A	IPsec Encapsulating Security Payload (ESP)

Table 11.17. Ports used for all-machine to control plane communications

Protocol	Port	Description
TCP	**6443**	Kubernetes API

Table 11.18. Ports used for control plane machine to control plane machine communications

Protocol	Port	Description
TCP	**2379-2380**	etcd server and peer ports

NTP configuration for user-provisioned infrastructure
OpenShift Container Platform clusters are configured to use a public Network Time Protocol (NTP) server by default. If you want to use a local enterprise NTP server, or if your cluster is being deployed in a disconnected network, you can configure the cluster to use a specific time server. For more information, see the documentation for *Configuring chrony time service* .

If a DHCP server provides NTP server information, the chrony time service on the Red Hat Enterprise Linux CoreOS (RHCOS) machines read the information and can sync the clock with the NTP servers.

Additional resources

- Configuring chrony time service

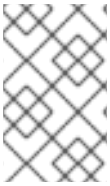
11.3.3.5. User-provisioned DNS requirements

In OpenShift Container Platform deployments, DNS name resolution is required for the following components:

- The Kubernetes API
- The OpenShift Container Platform application wildcard
- The bootstrap, control plane, and compute machines

Reverse DNS resolution is also required for the Kubernetes API, the bootstrap machine, the control plane machines, and the compute machines.

DNS A/AAAA or CNAME records are used for name resolution and PTR records are used for reverse name resolution. The reverse records are important because Red Hat Enterprise Linux CoreOS (RHCOS) uses the reverse records to set the hostnames for all the nodes, unless the hostnames are provided by DHCP. Additionally, the reverse records are used to generate the certificate signing requests (CSR) that OpenShift Container Platform needs to operate.



NOTE

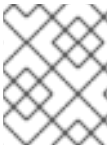
It is recommended to use a DHCP server to provide the hostnames to each cluster node. See the *DHCP recommendations for user-provisioned infrastructure* section for more information.

The following DNS records are required for a user-provisioned OpenShift Container Platform cluster and they must be in place before installation. In each record, **<cluster_name>** is the cluster name and **<base_domain>** is the base domain that you specify in the **install-config.yaml** file. A complete DNS record takes the form: **<component>.<cluster_name>.<base_domain>.**.

Table 11.19. Required DNS records

Component	Record	Description
Kubernetes API	**api.<cluster_name>.<base_domain>.**	A DNS A/AAAA or CNAME record, and a DNS PTR record, to identify the API load balancer. These records must be resolvable by both clients external to the cluster and from all the nodes within the cluster.
	api-int.<cluster_name>.<base_domain>.	A DNS A/AAAA or CNAME record, and a DNS PTR record, to internally identify the API load balancer. These records must be resolvable from all the nodes within the cluster.  IMPORTANT The API server must be able to resolve the worker nodes by the hostnames that are recorded in Kubernetes. If the API server cannot resolve the node names, then proxied API calls can fail, and you cannot retrieve logs from pods.
Routes	***.apps.<cluster_name>.<base_domain>.**	A wildcard DNS A/AAAA or CNAME record that refers to the application ingress load balancer. The application ingress load balancer targets the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default. These records must be resolvable by both clients external to the cluster and from all the nodes within the cluster. For example, **console-openshift-console.apps.<cluster_name>.<base_domain>** is used as a wildcard route to the OpenShift Container Platform console.
Bootstrap machine	**bootstrap.<cluster_name>.<base_domain>.**	A DNS A/AAAA or CNAME record, and a DNS PTR record, to identify the bootstrap machine. These records must be resolvable by the nodes within the cluster.

Component	Record	Description
Control plane machines	**<master><n>.<cluster_name>.<base_domain>.**	DNS A/AAAA or CNAME records and DNS PTR records to identify each machine for the control plane nodes. These records must be resolvable by the nodes within the cluster.
Compute machines	**<worker><n>.<cluster_name>.<base_domain>.**	DNS A/AAAA or CNAME records and DNS PTR records to identify each machine for the worker nodes. These records must be resolvable by the nodes within the cluster.



NOTE

In OpenShift Container Platform 4.4 and later, you do not need to specify etcd host and SRV records in your DNS configuration.

TIP

You can use the **dig** command to verify name and reverse name resolution. See the section on *Validating DNS resolution for user-provisioned infrastructure* for detailed validation steps.

11.3.3.5.1. Example DNS configuration for user-provisioned clusters

This section provides A and PTR record configuration samples that meet the DNS requirements for deploying OpenShift Container Platform on user-provisioned infrastructure. The samples are not meant to provide advice for choosing one DNS solution over another.

In the examples, the cluster name is **ocp4** and the base domain is **example.com**.

Example DNS A record configuration for a user-provisioned cluster

The following example is a BIND zone file that shows sample A records for name resolution in a user-provisioned cluster.

Example 11.4. Sample DNS zone database

```
$TTL 1W
@ IN SOA ns1.example.com. root (
   2019070700 ; serial
   3H  ; refresh (3 hours)
   30M  ; retry (30 minutes)
   2W  ; expiry (2 weeks)
   1W )  ; minimum (1 week)
 IN NS ns1.example.com.
 IN MX 10 smtp.example.com.
;
;
ns1.example.com.  IN A 192.168.1.5
smtp.example.com.  IN A 192.168.1.5
;
helper.example.com.  IN A 192.168.1.5
```

```
helper.ocp4.example.com. IN A 192.168.1.5
;
api.ocp4.example.com.  IN A 192.168.1.5 1
api-int.ocp4.example.com. IN A 192.168.1.5 2
;
*.apps.ocp4.example.com. IN A 192.168.1.5 3
;
bootstrap.ocp4.example.com. IN A 192.168.1.96 4
;
master0.ocp4.example.com. IN A 192.168.1.97 5
master1.ocp4.example.com. IN A 192.168.1.98 6
master2.ocp4.example.com. IN A 192.168.1.99 7
;
worker0.ocp4.example.com. IN A 192.168.1.11 8
worker1.ocp4.example.com. IN A 192.168.1.7 9
;
;EOF
```

1 Provides name resolution for the Kubernetes API. The record refers to the IP address of the API load balancer.

2 Provides name resolution for the Kubernetes API. The record refers to the IP address of the API load balancer and is used for internal cluster communications.

3 Provides name resolution for the wildcard routes. The record refers to the IP address of the application ingress load balancer. The application ingress load balancer targets the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.

NOTE

In the example, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

4 Provides name resolution for the bootstrap machine.

5 6 7 Provides name resolution for the control plane machines.

8 9 Provides name resolution for the compute machines.

Example DNS PTR record configuration for a user-provisioned cluster

The following example BIND zone file shows sample PTR records for reverse name resolution in a user-provisioned cluster.

Example 11.5. Sample DNS zone database for reverse records

```
$TTL 1W
@ IN SOA ns1.example.com. root (
  2019070700 ; serial
```

```
    3H  ; refresh (3 hours)
    30M  ; retry (30 minutes)
    2W  ; expiry (2 weeks)
    1W )  ; minimum (1 week)
 IN NS ns1.example.com.
;
5.1.168.192.in-addr.arpa. IN PTR api.ocp4.example.com. 1
5.1.168.192.in-addr.arpa. IN PTR api-int.ocp4.example.com. 2
;
96.1.168.192.in-addr.arpa. IN PTR bootstrap.ocp4.example.com. 3
;
97.1.168.192.in-addr.arpa. IN PTR master0.ocp4.example.com. 4
98.1.168.192.in-addr.arpa. IN PTR master1.ocp4.example.com. 5
99.1.168.192.in-addr.arpa. IN PTR master2.ocp4.example.com. 6
;
11.1.168.192.in-addr.arpa. IN PTR worker0.ocp4.example.com. 7
7.1.168.192.in-addr.arpa. IN PTR worker1.ocp4.example.com. 8
;
;EOF
```

1 Provides reverse DNS resolution for the Kubernetes API. The PTR record refers to the record name of the API load balancer.

2 Provides reverse DNS resolution for the Kubernetes API. The PTR record refers to the record name of the API load balancer and is used for internal cluster communications.

3 Provides reverse DNS resolution for the bootstrap machine.

4 5 6 Provides reverse DNS resolution for the control plane machines.

7 8 Provides reverse DNS resolution for the compute machines.

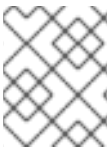
NOTE

A PTR record is not required for the OpenShift Container Platform application wildcard.

- Validating DNS resolution for user-provisioned infrastructure

11.3.3.6. Load balancing requirements for user-provisioned infrastructure

Before you install OpenShift Container Platform, you must provision the API and application ingress load balancing infrastructure. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.



NOTE

If you want to deploy the API and application Ingress load balancers with a Red Hat Enterprise Linux (RHEL) instance, you must purchase the RHEL subscription separately.

The load balancing infrastructure must meet the following requirements:

1. **API load balancer**: Provides a common endpoint for users, both human and machine, to interact with and configure the platform. Configure the following conditions:

   - Layer 4 load balancing only. This can be referred to as Raw TCP, SSL Passthrough, or SSL Bridge mode. If you use SSL Bridge mode, you must enable Server Name Indication (SNI) for the API routes.
   - A stateless load balancing algorithm. The options vary based on the load balancer implementation.

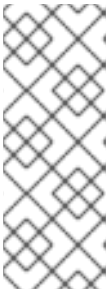
IMPORTANT

Do not configure session persistence for an API load balancer. Configuring session persistence for a Kubernetes API server might cause performance issues from excess application traffic for your OpenShift Container Platform cluster and the Kubernetes API that runs inside the cluster.

Configure the following ports on both the front and back of the load balancers:

Table 11.20. API load balancer

Port	Back-end machines (pool members)	Internal	External	Description
6443	Bootstrap and control plane. You remove the bootstrap machine from the load balancer after the bootstrap machine initializes the cluster control plane. You must configure the **/readyz** endpoint for the API server health check probe.	X	X	Kubernetes API server
22623	Bootstrap and control plane. You remove the bootstrap machine from the load balancer after the bootstrap machine initializes the cluster control plane.	X		Machine config server



NOTE

The load balancer must be configured to take a maximum of 30 seconds from the time the API server turns off the **/readyz** endpoint to the removal of the API server instance from the pool. Within the time frame after **/readyz** returns an error or becomes healthy, the endpoint must have been removed or added. Probing every 5 or 10 seconds, with two successful requests to become healthy and three to become unhealthy, are well-tested values.

2. **Application Ingress load balancer**: Provides an ingress point for application traffic flowing in from outside the cluster. A working configuration for the Ingress router is required for an OpenShift Container Platform cluster.
   Configure the following conditions:

- Layer 4 load balancing only. This can be referred to as Raw TCP, SSL Passthrough, or SSL Bridge mode. If you use SSL Bridge mode, you must enable Server Name Indication (SNI) for the ingress routes.
- A connection-based or session-based persistence is recommended, based on the options available and types of applications that will be hosted on the platform.

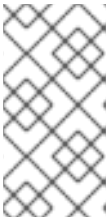
TIP

If the true IP address of the client can be seen by the application Ingress load balancer, enabling source IP-based session persistence can improve performance for applications that use end-to-end TLS encryption.

Configure the following ports on both the front and back of the load balancers:

Table 11.21. Application Ingress load balancer

Port	Back-end machines (pool members)	Internal	External	Description
443	The machines that run the Ingress Controller pods, compute, or worker, by default.	X	X	HTTPS traffic
80	The machines that run the Ingress Controller pods, compute, or worker, by default.	X	X	HTTP traffic



NOTE

If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application Ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes.

11.3.3.6.1. Example load balancer configuration for user-provisioned clusters

This section provides an example API and application ingress load balancer configuration that meets the load balancing requirements for user-provisioned clusters. The sample is an **/etc/haproxy/haproxy.cfg** configuration for an HAProxy load balancer. The example is not meant to provide advice for choosing one load balancing solution over another.

In the example, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

NOTE

If you are using HAProxy as a load balancer and SELinux is set to **enforcing**, you must ensure that the HAProxy service can bind to the configured TCP port by running **setsebool -P haproxy_connect_any=1**.

Example 11.6. Sample API and application Ingress load balancer configuration

```
global
  log         127.0.0.1 local2
  pidfile     /var/run/haproxy.pid
  maxconn     4000
  daemon
defaults
  mode                    http
  log                     global
  option                  dontlognull
  option http-server-close
  option                  redispatch
  retries                 3
  timeout http-request    10s
  timeout queue           1m
  timeout connect         10s
  timeout client          1m
  timeout server          1m
  timeout http-keep-alive 10s
  timeout check           10s
  maxconn                 3000
listen api-server-6443 (1)
  bind *:6443
  mode tcp
  server bootstrap bootstrap.ocp4.example.com:6443 check inter 1s backup (2)
  server master0 master0.ocp4.example.com:6443 check inter 1s
  server master1 master1.ocp4.example.com:6443 check inter 1s
  server master2 master2.ocp4.example.com:6443 check inter 1s
listen machine-config-server-22623 (3)
  bind *:22623
  mode tcp
  option  httpchk GET /readyz HTTP/1.0
  option  log-health-checks
  balance roundrobin
  server bootstrap bootstrap.ocp4.example.com:6443 verify none check check-ssl inter 10s fall 2
rise 3 backup (4)
  server master0 master0.ocp4.example.com:6443 weight 1 verify none check check-ssl inter 10s
fall 2 rise 3
  server master1 master1.ocp4.example.com:6443 weight 1 verify none check check-ssl inter 10s
fall 2 rise 3
  server master2 master2.ocp4.example.com:6443 weight 1 verify none check check-ssl inter 10s
fall 2 rise 3
listen ingress-router-443 (5)
  bind *:443
  mode tcp
  balance source
  server worker0 worker0.ocp4.example.com:443 check inter 1s
  server worker1 worker1.ocp4.example.com:443 check inter 1s
listen ingress-router-80 (6)
  bind *:80
  mode tcp
  balance source
  server worker0 worker0.ocp4.example.com:80 check inter 1s
  server worker1 worker1.ocp4.example.com:80 check inter 1s
```

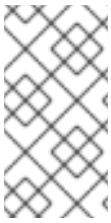
(1) Port **6443** handles the Kubernetes API traffic and points to the control plane machines.

2 4 The bootstrap entries must be in place before the OpenShift Container Platform cluster installation and they must be removed after the bootstrap process is complete.

3 Port **22623** handles the machine config server traffic and points to the control plane machines.

5 Port **443** handles the HTTPS traffic and points to the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.

6 Port **80** handles the HTTP traffic and points to the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.



NOTE

If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application Ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes.

TIP

If you are using HAProxy as a load balancer, you can check that the **haproxy** process is listening on ports **6443**, **22623**, **443**, and **80** by running **netstat -nltupe** on the HAProxy node.

11.3.4. Preparing the user-provisioned infrastructure

Before you install OpenShift Container Platform on user-provisioned infrastructure, you must prepare the underlying infrastructure.

This section provides details about the high-level steps required to set up your cluster infrastructure in preparation for an OpenShift Container Platform installation. This includes configuring IP networking and network connectivity for your cluster nodes, enabling the required ports through your firewall, and setting up the required DNS and load balancing infrastructure.

After preparation, your cluster infrastructure must meet the requirements outlined in the *Requirements for a cluster with user-provisioned infrastructure* section.

Prerequisites

- You have reviewed the OpenShift Container Platform 4.x Tested Integrations page.
- You have reviewed the infrastructure requirements detailed in the *Requirements for a cluster with user-provisioned infrastructure* section.

Procedure

1. If you are using DHCP to provide the IP networking configuration to your cluster nodes, configure your DHCP service.
    a. Add persistent IP addresses for the nodes to your DHCP server configuration. In your configuration, match the MAC address of the relevant network interface to the intended IP address for each node.

b. When you use DHCP to configure IP addressing for the cluster machines, the machines also obtain the DNS server information through DHCP. Define the persistent DNS server address that is used by the cluster nodes through your DHCP server configuration.

NOTE

If you are not using a DHCP service, you must provide the IP networking configuration and the address of the DNS server to the nodes at RHCOS install time. These can be passed as boot arguments if you are installing from an ISO image. See the *Installing RHCOS and starting the OpenShift Container Platform bootstrap process* section for more information about static IP provisioning and advanced networking options.

c. Define the hostnames of your cluster nodes in your DHCP server configuration. See the *Setting the cluster node hostnames through DHCP* section for details about hostname considerations.

NOTE

If you are not using a DHCP service, the cluster nodes obtain their hostname through a reverse DNS lookup.

2. Ensure that your network infrastructure provides the required network connectivity between the cluster components. See the *Networking requirements for user-provisioned infrastructure* section for details about the requirements.

3. Configure your firewall to enable the ports required for the OpenShift Container Platform cluster components to communicate. See *Networking requirements for user-provisioned infrastructure* section for details about the ports that are required.

IMPORTANT

By default, port **1936** is accessible for an OpenShift Container Platform cluster, because each control plane node needs access to this port.

Avoid using the Ingress load balancer to expose this port, because doing so might result in the exposure of sensitive information, such as statistics and metrics, related to Ingress Controllers.

4. Setup the required DNS infrastructure for your cluster.

   a. Configure DNS name resolution for the Kubernetes API, the application wildcard, the bootstrap machine, the control plane machines, and the compute machines.

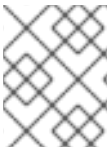
   b. Configure reverse DNS resolution for the Kubernetes API, the bootstrap machine, the control plane machines, and the compute machines.
   See the *User-provisioned DNS requirements* section for more information about the OpenShift Container Platform DNS requirements.

5. Validate your DNS configuration.

   a. From your installation node, run DNS lookups against the record names of the Kubernetes API, the wildcard routes, and the cluster nodes. Validate that the IP addresses in the responses correspond to the correct components.

b. From your installation node, run reverse DNS lookups against the IP addresses of the load balancer and the cluster nodes. Validate that the record names in the responses correspond to the correct components.
See the *Validating DNS resolution for user-provisioned infrastructure* section for detailed DNS validation steps.

6. Provision the required API and application ingress load balancing infrastructure. See the *Load balancing requirements for user-provisioned infrastructure* section for more information about the requirements.



NOTE

Some load balancing solutions require the DNS name resolution for the cluster nodes to be in place before the load balancing is initialized.

Additional resources

- Requirements for a cluster with user-provisioned infrastructure
- Installing RHCOS and starting the OpenShift Container Platform bootstrap process
- Setting the cluster node hostnames through DHCP
- Advanced RHCOS installation configuration
- Networking requirements for user-provisioned infrastructure
- User-provisioned DNS requirements
- Validating DNS resolution for user-provisioned infrastructure
- Load balancing requirements for user-provisioned infrastructure

11.3.5. Validating DNS resolution for user-provisioned infrastructure

You can validate your DNS configuration before installing OpenShift Container Platform on user-provisioned infrastructure.

IMPORTANT

The validation steps detailed in this section must succeed before you install your cluster.

Prerequisites

- You have configured the required DNS records for your user-provisioned infrastructure.

Procedure

1. From your installation node, run DNS lookups against the record names of the Kubernetes API, the wildcard routes, and the cluster nodes. Validate that the IP addresses contained in the responses correspond to the correct components.

   a. Perform a lookup against the Kubernetes API record name. Check that the result points to the IP address of the API load balancer:

```
$ dig +noall +answer @<nameserver_ip> api.<cluster_name>.<base_domain> 1
```

1 Replace **<nameserver_ip>** with the IP address of the nameserver, **<cluster_name>** with your cluster name, and **<base_domain>** with your base domain name.

Example output

```
api.ocp4.example.com.  604800 IN A 192.168.1.5
```

b. Perform a lookup against the Kubernetes internal API record name. Check that the result points to the IP address of the API load balancer:

```
$ dig +noall +answer @<nameserver_ip> api-int.<cluster_name>.<base_domain>
```

Example output

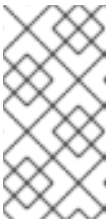
```
api-int.ocp4.example.com.  604800 IN A 192.168.1.5
```

c. Test an example ***.apps.<cluster_name>.<base_domain>** DNS wildcard lookup. All of the application wildcard lookups must resolve to the IP address of the application ingress load balancer:

```
$ dig +noall +answer @<nameserver_ip> random.apps.<cluster_name>.<base_domain>
```

Example output

```
random.apps.ocp4.example.com.  604800 IN A 192.168.1.5
```



NOTE

In the example outputs, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

You can replace **random** with another wildcard value. For example, you can query the route to the OpenShift Container Platform console:

```
$ dig +noall +answer @<nameserver_ip> console-openshift-console.apps.
<cluster_name>.<base_domain>
```

Example output

```
console-openshift-console.apps.ocp4.example.com. 604800 IN A 192.168.1.5
```

d. Run a lookup against the bootstrap DNS record name. Check that the result points to the IP address of the bootstrap node:

```
$ dig +noall +answer @<nameserver_ip> bootstrap.<cluster_name>.<base_domain>
```

Example output

```
bootstrap.ocp4.example.com.  604800 IN A 192.168.1.96
```

e. Use this method to perform lookups against the DNS record names for the control plane and compute nodes. Check that the results correspond to the IP addresses of each node.

2. From your installation node, run reverse DNS lookups against the IP addresses of the load balancer and the cluster nodes. Validate that the record names contained in the responses correspond to the correct components.

a. Perform a reverse lookup against the IP address of the API load balancer. Check that the response includes the record names for the Kubernetes API and the Kubernetes internal API:

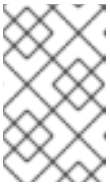
```
$ dig +noall +answer @<nameserver_ip> -x 192.168.1.5
```

Example output

```
5.1.168.192.in-addr.arpa. 604800 IN PTR api-int.ocp4.example.com. 1
5.1.168.192.in-addr.arpa. 604800 IN PTR api.ocp4.example.com. 2
```

1 Provides the record name for the Kubernetes internal API.

2 Provides the record name for the Kubernetes API.



NOTE

A PTR record is not required for the OpenShift Container Platform application wildcard. No validation step is needed for reverse DNS resolution against the IP address of the application ingress load balancer.

b. Perform a reverse lookup against the IP address of the bootstrap node. Check that the result points to the DNS record name of the bootstrap node:

```
$ dig +noall +answer @<nameserver_ip> -x 192.168.1.96
```

Example output

```
96.1.168.192.in-addr.arpa. 604800 IN PTR bootstrap.ocp4.example.com.
```

c. Use this method to perform reverse lookups against the IP addresses for the control plane and compute nodes. Check that the results correspond to the DNS record names of each node.

Additional resources

- User-provisioned DNS requirements
- Load balancing requirements for user-provisioned infrastructure

11.3.6. Generating a key pair for cluster node SSH access

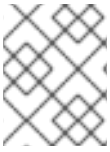
During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the **~/.ssh/authorized_keys** list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The **./openshift-install gather** command also requires the SSH public key to be in place on the cluster nodes.

IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.



NOTE

You must use a local key, not one that you configured with platform-specific approaches such as AWS key pairs.

Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N '' -f <path>/<file_name> 1
```

1 Specify the path and file name, such as **~/.ssh/id_ed25519**, of the new SSH key. If you have an existing key pair, ensure your public key is in the your **~/.ssh** directory.

NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS validated or Modules In Process cryptographic libraries on the **x86_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the **~/.ssh/id_ed25519.pub** public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the **./openshift-install gather** command.

NOTE

On some distributions, default SSH private key identities such as **~/.ssh/id_rsa** and **~/.ssh/id_dsa** are managed automatically.

   a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

Example output

```
Agent pid 31874
```

NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

1 Specify the path and file name for your SSH private key, such as **~/.ssh/id_ed25519**

Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

Additional resources

- Verifying node health

11.3.7. Obtaining the installation program

Before you install OpenShift Container Platform, download the installation file on a local computer.

Prerequisites

- You have a computer that runs Linux or macOS, with 500 MB of local disk space.

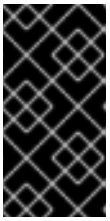
Procedure

Procedure

1. Access the Infrastructure Provider page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.

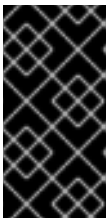
2. Select your infrastructure provider.

3. Navigate to the page for your installation type, download the installation program that corresponds with your host operating system and architecture, and place the file in the directory where you will store the installation configuration files.



IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.



IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

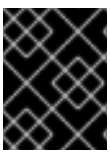
4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation pull secret from the Red Hat OpenShift Cluster Manager . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

11.3.8. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.



IMPORTANT

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.11. Download and install the new version of **oc**.

Installing the OpenShift CLI on Linux

You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.

2. Select the architecture in the **Product Variant** drop-down menu.

3. Select the appropriate version in the **Version** drop-down menu.
4. Click **Download Now** next to the **OpenShift v4.11 Linux Client** entry and save the file.
5. Unpack the archive:

```
$ tar xvf <file>
```

6. Place the **oc** binary in a directory that is on your **PATH**.
   To check your **PATH**, execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.
   To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
C:\> oc <command>
```

Installing the OpenShift CLI on macOS

You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.

3. Click **Download Now** next to the **OpenShift v4.11 macOS Client** entry and save the file.

NOTE

For macOS arm64, choose the **OpenShift v4.11 macOS arm64 Client** entry.

4. Unpack and unzip the archive.

5. Move the **oc** binary to a directory on your PATH.
To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

11.3.9. Manually creating the installation configuration file

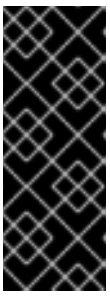
Prerequisites

- You have an SSH public key on your local machine to provide to the installation program. The key will be used for SSH authentication onto your cluster nodes for debugging and disaster recovery.
- You have obtained the OpenShift Container Platform installation program and the pull secret for your cluster.

Procedure

1. Create an installation directory to store your required installation assets in:

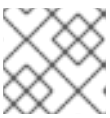
```
$ mkdir <installation_directory>
```



IMPORTANT

You must create a directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

2. Customize the sample **install-config.yaml** file template that is provided and save it in the **<installation_directory>**.



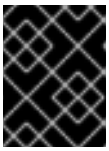
NOTE

You must name this configuration file **install-config.yaml**.

NOTE

For some platform types, you can alternatively run **./openshift-install create install-config --dir <installation_directory>** to generate an **install-config.yaml** file. You can provide details about your cluster configuration at the prompts.

3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.



IMPORTANT

The **install-config.yaml** file is consumed during the next step of the installation process. You must back it up now.

11.3.9.1. Installation configuration parameters

Before you deploy an OpenShift Container Platform cluster, you provide a customized **install-config.yaml** installation configuration file that describes the details for your environment.

NOTE

After installation, you cannot modify these parameters in the **install-config.yaml** file.

11.3.9.1.1. Required configuration parameters

Required installation configuration parameters are described in the following table:

Table 11.22. Required parameters

Parameter	Description	Values
apiVersion	The API version for the **install-config.yaml** content. The current version is **v1**. The installer may also support older API versions.	String
baseDomain	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the **baseDomain** and **metadata.name** parameter values that uses the **<metadata.name>.<baseDomain>** format.	A fully-qualified domain or subdomain name, such as **example.com**.

Parameter	Description	Values
metadata	Kubernetes resource **ObjectMeta**, from which only the **name** parameter is consumed.	Object
metadata.name	The name of the cluster. DNS records for the cluster are all subdomains of **{{.metadata.name}}.{{.baseDomain}}**.	String of lowercase letters and hyphens (**-**), such as **dev**.
platform	The configuration for the specific platform upon which to perform the installation: **alibabacloud**, **aws**, **baremetal**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**. For additional information about **platform.<platform>** parameters, consult the table for your specific platform that follows.	Object
pullSecret	Get a pull secret from the Red Hat OpenShift Cluster Manager to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	{ "auths":{ "cloud.openshift.com":{ "auth":"b3Blb=", "email":"you@example.com" }, "quay.io":{ "auth":"b3Blb=", "email":"you@example.com" } } }

11.3.9.1.2. Network configuration parameters

You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

- If you use the OVN-Kubernetes cluster network provider, both IPv4 and IPv6 address families are supported.
- If you use the OpenShift SDN cluster network provider, only the IPv4 address family is supported.

If you configure your cluster to use both IP address families, review the following requirements:

- Both IP families must use the same network interface for the default gateway.
- Both IP families must have the default gateway.
- You must specify IPv4 and IPv6 addresses in the same order for all network configuration parameters. For example, in the following configuration IPv4 addresses are listed before IPv6 addresses.

```
networking:
  clusterNetwork:
  - cidr: 10.128.0.0/14
    hostPrefix: 23
  - cidr: fd00:10:128::/56
    hostPrefix: 64
  serviceNetwork:
  - 172.30.0.0/16
  - fd00:172:16::/112
```

NOTE

Globalnet is not supported with Red Hat OpenShift Data Foundation disaster recovery solutions. For regional disaster recovery scenarios, ensure that you use a nonoverlapping range of private IP addresses for the cluster and service networks in each cluster.

Table 11.23. Network parameters

Parameter	Description	Values
networking	The configuration for the cluster network.	Object  **NOTE** You cannot modify parameters specified by the **networking** object after installation.
networking.networkType	The cluster network provider Container Network Interface (CNI) cluster network provider to install.	Either **OpenShiftSDN** or **OVNKubernetes**. **OpenShiftSDN** is a CNI provider for all-Linux networks. **OVNKubernetes** is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is **OpenShiftSDN**.

Parameter	Description	Values
networking.clusterNetwork	The IP address blocks for pods. The default value is **10.128.0.0/14** with a host prefix of **/23**. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: `networking:` `  clusterNetwork:` `  - cidr: 10.128.0.0/14` `    hostPrefix: 23` `  - cidr: fd01::/48` `    hostPrefix: 64`
networking.clusterNetwork.cidr	Required if you use **networking.clusterNetwork**. An IP address block. If you use the OpenShift SDN network provider, specify an IPv4 network. If you use the OVN-Kubernetes network provider, you can specify IPv4 and IPv6 networks.	An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between **0** and **32**. The prefix length for an IPv6 block is between **0** and **128**. For example, **10.128.0.0/14** or **fd01::/48**.
networking.clusterNetwork.hostPrefix	The subnet prefix length to assign to each individual node. For example, if **hostPrefix** is set to **23** then each node is assigned a **/23** subnet out of the given **cidr**. A **hostPrefix** value of **23** provides 510 (2^(32 - 23) - 2) pod IP addresses.	A subnet prefix. For an IPv4 network the default value is **23**. For an IPv6 network the default value is **64**. The default value is also the minimum value for IPv6.
networking.serviceNetwork	The IP address block for services. The default value is **172.30.0.0/16**. The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network. If you use the OVN-Kubernetes network provider, you can specify an IP address block for both of the IPv4 and IPv6 address families.	An array with an IP address block in CIDR format. For example: `networking:` `  serviceNetwork:` `  - 172.30.0.0/16` `  - fd02::/112`
networking.machineNetwork	The IP address blocks for machines. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: `networking:` `  machineNetwork:` `  - cidr: 10.0.0.0/16`

Parameter	Description	Values
networking.machineNetwork.cidr	Required if you use **networking.machineNetwork**. An IP address block. The default value is **10.0.0.0/16** for all platforms other than libvirt. For libvirt, the default value is **192.168.126.0/24**.	An IP network block in CIDR notation. For example, **10.0.0.0/16** or **fd00::/48**.  **NOTE** Set the **networking.machineNetwork** to match the CIDR that the preferred NIC resides in.

11.3.9.1.3. Optional configuration parameters

Optional installation configuration parameters are described in the following table:

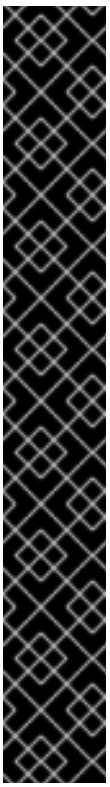
Table 11.24. Optional parameters

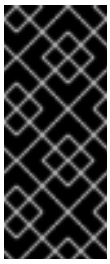
Parameter	Description	Values
additionalTrustBundle	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String
capabilities	Controls the installation of optional core cluster components. You can reduce the footprint of your OpenShift Container Platform cluster by disabling optional components.	String array
capabilities.baselineCapabilitySet	Selects an initial set of optional capabilities to enable. Valid values are **None**, **v4.11** and **vCurrent**. **v4.11** enables the **baremetal** Operator, the **marketplace** Operator, and the **openshift-samples** content. **vCurrent** installs the recommended set of capabilities for the current version of OpenShift Container Platform. The default value is **vCurrent**.	String

Parameter	Description	Values
capabilities.additionalEnabledCapabilities	Extends the set of optional capabilities beyond what you specify in **baselineCapabilitySet**. Valid values are **baremetal**, **marketplace** and **openshift-samples**. You may specify multiple capabilities in this parameter.	String array
cgroupsV2	Enables Linux control groups version 2 (cgroups v2) on specific nodes in your cluster. The OpenShift Container Platform process for enabling cgroups v2 disables all cgroup version 1 controllers and hierarchies. The OpenShift Container Platform cgroups version 2 feature is in Developer Preview and is not supported by Red Hat at this time.	**true**
compute	The configuration for the machines that comprise the compute nodes.	Array of **MachinePool** objects.
compute.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** and **arm64**.	String
compute.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  **IMPORTANT** If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**

Parameter	Description	Values
compute.name	Required if you use **compute**. The name of the machine pool.	**worker**
compute.platform	Required if you use **compute**. Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the **controlPlane.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
compute.replicas	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to **2**. The default value is **3**.
controlPlane	The configuration for the machines that comprise the control plane.	Array of **MachinePool** objects.
controlPlane.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** and **arm64**.	String
controlPlane.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  IMPORTANT If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
controlPlane.name	Required if you use **controlPlane**. The name of the machine pool.	**master**

Parameter	Description	Values
controlPlane.platform	Required if you use **controlPlane**. Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the **compute.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
controlPlane.replicas	The number of control plane machines to provision.	The only supported value is **3**, which is the default value.
credentialsMode	The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported.  **NOTE** Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the *Cloud Credential Operator* entry in the *Cluster Operators reference* content.  **NOTE** If your AWS account has service control policies (SCP) enabled, you must configure the **credentialsMode** parameter to **Mint**, **Passthrough** or **Manual**.	**Mint**, **Passthrough**, **Manual** or an empty string (**""**).

Parameter	Description	Values
fips	Enable or disable FIPS mode. The default is **false** (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.  **IMPORTANT** To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.  **NOTE** If you are using Azure File storage, you cannot enable FIPS mode.	**false** or **true**
imageContentSources	Sources and repositories for the release-image content.	Array of objects. Includes a **source** and, optionally, **mirrors**, as described in the following rows of this table.
imageContentSources.source	Required if you use **imageContentSources**. Specify the repository that users refer to, for example, in image pull specifications.	String

Parameter	Description	Values
imageContentSources.mirrors	Specify one or more repositories that may also contain the same images.	Array of strings
publish	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	**Internal** or **External**. The default value is **External**. Setting this field to **Internal** is not supported on non-cloud platforms and IBM Cloud VPC.  **IMPORTANT** If the value of the field is set to **Internal**, the cluster will become non-functional. For more information, refer to BZ#1953035.
sshKey	The SSH key to authenticate access to your cluster machines.  **NOTE** For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.	For example, **sshKey: ssh-ed25519 AAAA..**.

11.3.9.2. Sample install-config.yaml file for bare metal

You can customize the **install-config.yaml** file to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.

```
apiVersion: v1
baseDomain: example.com (1)
compute: (2)
- hyperthreading: Enabled (3)
  name: worker
  replicas: 0 (4)
controlPlane: (5)
  hyperthreading: Enabled (6)
  name: master
  replicas: 3 (7)
```

```
metadata:
  name: test 8
networking:
  clusterNetwork:
  - cidr: 10.128.0.0/14 9
    hostPrefix: 23 10
  networkType: OpenShiftSDN
  serviceNetwork: 11
  - 172.30.0.0/16
platform:
  none: {} 12
fips: false 13
pullSecret: '{"auths": ...}' 14
sshKey: 'ssh-ed25519 AAAA...' 15
```

1 The base domain of the cluster. All DNS records must be sub-domains of this base and include the cluster name.

2 5 The **controlPlane** section is a single mapping, but the **compute** section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, **-**, and the first line of the **controlPlane** section must not. Only one control plane pool is used.

3 6 Specifies whether to enable or disable simultaneous multithreading (SMT), or hyperthreading. By default, SMT is enabled to increase the performance of the cores in your machines. You can disable it by setting the parameter value to **Disabled**. If you disable SMT, you must disable it in all cluster machines; this includes both control plane and compute machines.

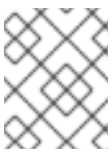
NOTE

Simultaneous multithreading (SMT) is enabled by default. If SMT is not enabled in your BIOS settings, the **hyperthreading** parameter has no effect.

IMPORTANT

If you disable **hyperthreading**, whether in the BIOS or in the **install-config.yaml** file, ensure that your capacity planning accounts for the dramatically decreased machine performance.

4 You must set this value to **0** when you install OpenShift Container Platform on user-provisioned infrastructure. In installer-provisioned installations, the parameter controls the number of compute machines that the cluster creates and manages for you. In user-provisioned installations, you must manually deploy the compute machines before you finish installing the cluster.



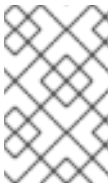
NOTE

If you are installing a three-node cluster, do not deploy any compute machines when you install the Red Hat Enterprise Linux CoreOS (RHCOS) machines.

7 The number of control plane machines that you add to the cluster. Because the cluster uses these values as the number of etcd endpoints in the cluster, the value must match the number of control plane machines that you deploy.

8 The cluster name that you specified in your DNS records.

9 A block of IP addresses from which pod IP addresses are allocated. This block must not overlap with existing physical networks. These IP addresses are used for the pod network. If you need to access the pods from an external network, you must configure load balancers and routers to manage the traffic.



NOTE

Class E CIDR range is reserved for a future use. To use the Class E CIDR range, you must ensure your networking environment accepts the IP addresses within the Class E CIDR range.

10 The subnet prefix length to assign to each individual node. For example, if **hostPrefix** is set to **23**, then each node is assigned a **/23** subnet out of the given **cidr**, which allows for 510 (2^(32 - 23) - 2) pod IP addresses. If you are required to provide access to nodes from an external network, configure load balancers and routers to manage the traffic.

11 The IP address pool to use for service IP addresses. You can enter only one IP address pool. This block must not overlap with existing physical networks. If you need to access the services from an external network, configure load balancers and routers to manage the traffic.

12 You must set the platform to **none**. You cannot provide additional platform configuration variables for your platform.

IMPORTANT

Clusters that are installed with the platform type **none** are unable to use some features, such as managing compute machines with the Machine API. This limitation applies even if the compute machines that are attached to the cluster are installed on a platform that would normally support the feature. This parameter cannot be changed after installation.

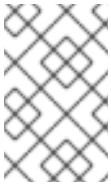
13 Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.

IMPORTANT

To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.

14 The pull secret from the Red Hat OpenShift Cluster Manager . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

15 The SSH public key for the **core** user in Red Hat Enterprise Linux CoreOS (RHCOS).



NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

Additional resources

- See Load balancing requirements for user-provisioned infrastructure for more information on the API and application ingress load balancing requirements.

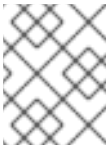
11.3.10. Network configuration phases

There are two phases prior to OpenShift Container Platform installation where you can customize the network configuration.

Phase 1

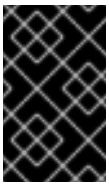
You can customize the following network-related fields in the **install-config.yaml** file before you create the manifest files:

- **networking.networkType**
- **networking.clusterNetwork**
- **networking.serviceNetwork**
- **networking.machineNetwork**
  For more information on these fields, refer to *Installation configuration parameters*.



NOTE

Set the **networking.machineNetwork** to match the CIDR that the preferred NIC resides in.



IMPORTANT

The CIDR range **172.17.0.0/16** is reserved by libVirt. You cannot use this range or any range that overlaps with this range for any networks in your cluster.

Phase 2

After creating the manifest files by running **openshift-install create manifests**, you can define a customized Cluster Network Operator manifest with only the fields you want to modify. You can use the manifest to specify advanced network configuration.

You cannot override the values specified in phase 1 in the **install-config.yaml** file during phase 2. However, you can further customize the cluster network provider during phase 2.

11.3.11. Specifying advanced network configuration

You can use advanced network configuration for your cluster network provider to integrate your cluster into your existing network environment. You can specify advanced network configuration only before you install the cluster.

IMPORTANT

Customizing your network configuration by modifying the OpenShift Container Platform manifest files created by the installation program is not supported. Applying a manifest file that you create, as in the following procedure, is supported.

Prerequisites

- You have created the **install-config.yaml** file and completed any modifications to it.

Procedure

1. Change to the directory that contains the installation program and create the manifests:

```
$ ./openshift-install create manifests --dir <installation_directory> 1
```

1 **<installation_directory>** specifies the name of the directory that contains the **install-config.yaml** file for your cluster.

2. Create a stub manifest file for the advanced network configuration that is named **cluster-network-03-config.yml** in the **<installation_directory>/manifests/** directory:

```
apiVersion: operator.openshift.io/v1
kind: Network
metadata:
  name: cluster
spec:
```

3. Specify the advanced network configuration for your cluster in the **cluster-network-03-config.yml** file, such as in the following examples:

Specify a different VXLAN port for the OpenShift SDN network provider

```
apiVersion: operator.openshift.io/v1
kind: Network
metadata:
  name: cluster
spec:
  defaultNetwork:
    openshiftSDNConfig:
      vxlanPort: 4800
```

Enable IPsec for the OVN-Kubernetes network provider

```
apiVersion: operator.openshift.io/v1
kind: Network
metadata:
  name: cluster
spec:
```

```
defaultNetwork:
  ovnKubernetesConfig:
    ipsecConfig: {}
```

4. Optional: Back up the **manifests/cluster-network-03-config.yml** file. The installation program consumes the **manifests/** directory when you create the Ignition config files.

11.3.12. Cluster Network Operator configuration

The configuration for the cluster network is specified as part of the Cluster Network Operator (CNO) configuration and stored in a custom resource (CR) object that is named **cluster**. The CR specifies the fields for the **Network** API in the **operator.openshift.io** API group.

The CNO configuration inherits the following fields during cluster installation from the **Network** API in the **Network.config.openshift.io** API group and these fields cannot be changed:

clusterNetwork

IP address pools from which pod IP addresses are allocated.

serviceNetwork

IP address pool for services.

defaultNetwork.type

Cluster network provider, such as OpenShift SDN or OVN-Kubernetes.

You can specify the cluster network provider configuration for your cluster by setting the fields for the **defaultNetwork** object in the CNO object named **cluster**.

11.3.12.1. Cluster Network Operator configuration object

The fields for the Cluster Network Operator (CNO) are described in the following table:

Table 11.25. Cluster Network Operator configuration object

Field	Type	Description
metadata.name	**string**	The name of the CNO object. This name is always **cluster**.
spec.clusterNetwork	**array**	A list specifying the blocks of IP addresses from which pod IP addresses are allocated and the subnet prefix length assigned to each individual node in the cluster. For example: `spec:` `  clusterNetwork:` `  - cidr: 10.128.0.0/19` `  hostPrefix: 23` `  - cidr: 10.128.32.0/19` `  hostPrefix: 23` You can customize this field only in the **install-config.yaml** file before you create the manifests. The value is read-only in the manifest file.

Field	Type	Description
spec.serviceNetwork	**array**	A block of IP addresses for services. The OpenShift SDN and OVN-Kubernetes Container Network Interface (CNI) network providers support only a single IP address block for the service network. For example: `spec:` `  serviceNetwork:` `  - 172.30.0.0/14` You can customize this field only in the **install-config.yaml** file before you create the manifests. The value is read-only in the manifest file.
spec.defaultNetwork	**object**	Configures the Container Network Interface (CNI) cluster network provider for the cluster network.
spec.kubeProxyConfig	**object**	The fields for this object specify the kube-proxy configuration. If you are using the OVN-Kubernetes cluster network provider, the kube-proxy configuration has no effect.

defaultNetwork object configuration

The values for the **defaultNetwork** object are defined in the following table:

Table 11.26. defaultNetwork object

Field	Type	Description
type	**string**	Either **OpenShiftSDN** or **OVNKubernetes**. The cluster network provider is selected during installation. This value cannot be changed after cluster installation. **NOTE** OpenShift Container Platform uses the OpenShift SDN Container Network Interface (CNI) cluster network provider by default.
openshiftSDNConfig	**object**	This object is only valid for the OpenShift SDN cluster network provider.
ovnKubernetesConfig	**object**	This object is only valid for the OVN-Kubernetes cluster network provider.

Configuration for the OpenShift SDN CNI cluster network provider

The following table describes the configuration fields for the OpenShift SDN Container Network Interface (CNI) cluster network provider.

Table 11.27. openshiftSDNConfig object

Field	Type	Description
mode	**string**	Configures the network isolation mode for OpenShift SDN. The default value is **NetworkPolicy**. The values **Multitenant** and **Subnet** are available for backwards compatibility with OpenShift Container Platform 3.x but are not recommended. This value cannot be changed after cluster installation.
mtu	**integer**	The maximum transmission unit (MTU) for the VXLAN overlay network. This is detected automatically based on the MTU of the primary network interface. You do not normally need to override the detected MTU. If the auto-detected value is not what you expect it to be, confirm that the MTU on the primary network interface on your nodes is correct. You cannot use this option to change the MTU value of the primary network interface on the nodes. If your cluster requires different MTU values for different nodes, you must set this value to **50** less than the lowest MTU value in your cluster. For example, if some nodes in your cluster have an MTU of **9001**, and some have an MTU of**1500**, you must set this value to **1450**. This value cannot be changed after cluster installation.
vxlanPort	**integer**	The port to use for all VXLAN packets. The default value is **4789**. This value cannot be changed after cluster installation. If you are running in a virtualized environment with existing nodes that are part of another VXLAN network, then you might be required to change this. For example, when running an OpenShift SDN overlay on top of VMware NSX-T, you must select an alternate port for the VXLAN, because both SDNs use the same default VXLAN port number. On Amazon Web Services (AWS), you can select an alternate port for the VXLAN between port **9000** and port **9999**.

Example OpenShift SDN configuration

```
defaultNetwork:
  type: OpenShiftSDN
  openshiftSDNConfig:
    mode: NetworkPolicy
    mtu: 1450
    vxlanPort: 4789
```

Configuration for the OVN-Kubernetes CNI cluster network provider

The following table describes the configuration fields for the OVN-Kubernetes CNI cluster network provider.

Table 11.28. **ovnKubernetesConfig** object

Field	Type	Description
mtu	**integer**	The maximum transmission unit (MTU) for the Geneve (Generic Network Virtualization Encapsulation) overlay network. This is detected automatically based on the MTU of the primary network interface. You do not normally need to override the detected MTU. If the auto-detected value is not what you expect it to be, confirm that the MTU on the primary network interface on your nodes is correct. You cannot use this option to change the MTU value of the primary network interface on the nodes. If your cluster requires different MTU values for different nodes, you must set this value to **100** less than the lowest MTU value in your cluster. For example, if some nodes in your cluster have an MTU of **9001**, and some have an MTU of**1500**, you must set this value to **1400**.
genevePort	**integer**	The port to use for all Geneve packets. The default value is **6081**. This value cannot be changed after cluster installation.
ipsecConfig	**object**	Specify an empty object to enable IPsec encryption.
policyAuditConfig	**object**	Specify a configuration object for customizing network policy audit logging. If unset, the defaults audit log settings are used.
gatewayConfig	**object**	Optional: Specify a configuration object for customizing how egress traffic is sent to the node gateway.  **NOTE** While migrating egress traffic, you can expect some disruption to workloads and service traffic until the Cluster Network Operator (CNO) successfully rolls out the changes.

Table 11.29. **policyAuditConfig** object

Field	Type	Description
rateLimit	integer	The maximum number of messages to generate every second per node. The default value is **20** messages per second.

Field	Type	Description
maxFileSize	integer	The maximum size for the audit log in bytes. The default value is **50000000** or 50 MB.
destination	string	One of the following additional audit log targets: **libc** The libc **syslog()** function of the journald process on the host. **udp:<host>:<port>** A syslog server. Replace **<host>:<port>** with the host and port of the syslog server. **unix:<file>** A Unix Domain Socket file specified by **<file>**. **null** Do not send the audit logs to any additional target.
syslogFacility	string	The syslog facility, such as **kern**, as defined by RFC5424. The default value is **local0**.

Table 11.30. **gatewayConfig** object

Field	Type	Description
routingViaHost	**boolean**	Set this field to **true** to send egress traffic from pods to the host networking stack. For highly-specialized installations and applications that rely on manually configured routes in the kernel routing table, you might want to route egress traffic to the host networking stack. By default, egress traffic is processed in OVN to exit the cluster and is not affected by specialized routes in the kernel routing table. The default value is **false**. This field has an interaction with the Open vSwitch hardware offloading feature. If you set this field to **true**, you do not receive the performance benefits of the offloading because egress traffic is processed by the host networking stack.

Example OVN-Kubernetes configuration with IPSec enabled

```
defaultNetwork:
  type: OVNKubernetes
  ovnKubernetesConfig:
    mtu: 1400
    genevePort: 6081
    ipsecConfig: {}
```

kubeProxyConfig object configuration
The values for the **kubeProxyConfig** object are defined in the following table:

Table 11.31. **kubeProxyConfig** object

Field	Type	Description
iptablesSyncPeriod	**string**	The refresh period for **iptables** rules. The default value is **30s**. Valid suffixes include **s**, **m**, and **h** and are described in the Go **time** package documentation. **NOTE** Because of performance improvements introduced in OpenShift Container Platform 4.3 and greater, adjusting the **iptablesSyncPeriod** parameter is no longer necessary.
proxyArguments.iptables-min-sync-period	**array**	The minimum duration before refreshing **iptables** rules. This field ensures that the refresh does not happen too frequently. Valid suffixes include **s**, **m**, and **h** and are described in the Go **time** package. The default value is: `kubeProxyConfig:` `  proxyArguments:` `  iptables-min-sync-period:` `  - 0s`

11.3.13. Creating the Ignition config files

Because you must manually start the cluster machines, you must generate the Ignition config files that the cluster needs to make its machines.

IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.

Procedure

- Obtain the Ignition config files:

```
$ ./openshift-install create ignition-configs --dir <installation_directory> 1
```

1 For **<installation_directory>**, specify the directory name to store the files that the installation program creates.

IMPORTANT

If you created an **install-config.yaml** file, specify the directory that contains it. Otherwise, specify an empty directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

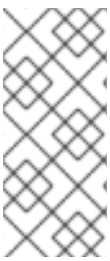
The following files are generated in the directory:

```
.
├── auth
│   ├── kubeadmin-password
│   └── kubeconfig
├── bootstrap.ign
├── master.ign
├── metadata.json
└── worker.ign
```

11.3.14. Installing RHCOS and starting the OpenShift Container Platform bootstrap process

To install OpenShift Container Platform on bare metal infrastructure that you provision, you must install Red Hat Enterprise Linux CoreOS (RHCOS) on the machines. When you install RHCOS, you must provide the Ignition config file that was generated by the OpenShift Container Platform installation program for the type of machine you are installing. If you have configured suitable networking, DNS, and load balancing infrastructure, the OpenShift Container Platform bootstrap process begins automatically after the RHCOS machines have rebooted.

To install RHCOS on the machines, follow either the steps to use an ISO image or network PXE booting.



NOTE

The compute node deployment steps included in this installation document are RHCOS-specific. If you choose instead to deploy RHEL-based compute nodes, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks. Only RHEL 8 compute machines are supported.

You can configure RHCOS during ISO and PXE installations by using the following methods:

- Kernel arguments: You can use kernel arguments to provide installation-specific information. For example, you can specify the locations of the RHCOS installation files that you uploaded to your HTTP server and the location of the Ignition config file for the type of node you are installing. For a PXE installation, you can use the **APPEND** parameter to pass the arguments to the kernel of the live installer. For an ISO installation, you can interrupt the live installation boot process to add the kernel arguments. In both installation cases, you can use special **coreos.inst.*** arguments to direct the live installer, as well as standard installation boot arguments for turning standard kernel services on or off.

- Ignition configs: OpenShift Container Platform Ignition config files (***.ign**) are specific to the type of node you are installing. You pass the location of a bootstrap, control plane, or compute node Ignition config file during the RHCOS installation so that it takes effect on first boot. In special cases, you can create a separate, limited Ignition config to pass to the live system. That Ignition config could do a certain set of tasks, such as reporting success to a provisioning system after completing installation. This special Ignition config is consumed by the **coreos-installer** to be applied on first boot of the installed system. Do not provide the standard control plane and compute node Ignition configs to the live ISO directly.

- **coreos-installer**: You can boot the live ISO installer to a shell prompt, which allows you to prepare the permanent system in a variety of ways before first boot. In particular, you can run the **coreos-installer** command to identify various artifacts to include, work with disk partitions, and set up networking. In some cases, you can configure features on the live system and copy them to the installed system.

Whether to use an ISO or PXE install depends on your situation. A PXE install requires an available DHCP service and more preparation, but can make the installation process more automated. An ISO install is a more manual process and can be inconvenient if you are setting up more than a few machines.

NOTE

As of OpenShift Container Platform 4.6, the RHCOS ISO and other installation artifacts provide support for installation on disks with 4K sectors.

11.3.14.1. Installing RHCOS by using an ISO image

You can use an ISO image to install RHCOS on the machines.

Prerequisites

- You have created the Ignition config files for your cluster.
- You have configured suitable network, DNS and load balancing infrastructure.
- You have an HTTP server that can be accessed from your computer, and from the machines that you create.
- You have reviewed the *Advanced RHCOS installation configuration* section for different ways to configure features, such as networking and disk partitioning.

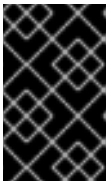
Procedure

1. Obtain the SHA512 digest for each of your Ignition config files. For example, you can use the following on a system running Linux to get the SHA512 digest for your **bootstrap.ign** Ignition config file:

```
$ sha512sum <installation_directory>/bootstrap.ign
```

The digests are provided to the **coreos-installer** in a later step to validate the authenticity of the Ignition config files on the cluster nodes.

2. Upload the bootstrap, control plane, and compute node Ignition config files that the installation program created to your HTTP server. Note the URLs of these files.



IMPORTANT

You can add or change configuration settings in your Ignition configs before saving them to your HTTP server. If you plan to add more compute machines to your cluster after you finish installation, do not delete these files.

3. From the installation host, validate that the Ignition config files are available on the URLs. The following example gets the Ignition config file for the bootstrap node:

```
$ curl -k http://<HTTP_server>/bootstrap.ign 1
```

Example output

```
  % Total    % Received % Xferd  Average Speed   Time    Time     Time  Current
                                 Dload  Upload   Total   Spent    Left  Speed
  0     0    0     0    0     0      0      0 --:--:-- --:--:-- --:--:--     0{"ignition":
{"version":"3.2.0"},"passwd":{"users":[{"name":"core","sshAuthorizedKeys":["ssh-rsa...
```

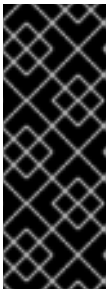
Replace **bootstrap.ign** with **master.ign** or **worker.ign** in the command to validate that the Ignition config files for the control plane and compute nodes are also available.

4. Although it is possible to obtain the RHCOS images that are required for your preferred method of installing operating system instances from the RHCOS image mirror page, the recommended way to obtain the correct version of your RHCOS images are from the output of **openshift-install** command:

```
$ openshift-install coreos print-stream-json | grep '\.iso[^.]'
```

Example output

```
"location": "<url>/art/storage/releases/rhcos-4.11-aarch64/<release>/aarch64/rhcos-
<release>-live.aarch64.iso",
"location": "<url>/art/storage/releases/rhcos-4.11-ppc64le/<release>/ppc64le/rhcos-
<release>-live.ppc64le.iso",
"location": "<url>/art/storage/releases/rhcos-4.11-s390x/<release>/s390x/rhcos-<release>-
live.s390x.iso",
"location": "<url>/art/storage/releases/rhcos-4.11/<release>/x86_64/rhcos-<release>-
live.x86_64.iso",
```



IMPORTANT

The RHCOS images might not change with every release of OpenShift Container Platform. You must download images with the highest version that is less than or equal to the OpenShift Container Platform version that you install. Use the image versions that match your OpenShift Container Platform version if they are available. Use only ISO images for this procedure. RHCOS qcow2 images are not supported for this installation type.

ISO file names resemble the following example:

rhcos-<version>-live.<architecture>.iso

5. Use the ISO to start the RHCOS installation. Use one of the following installation options:
   - Burn the ISO image to a disk and boot it directly.
   - Use ISO redirection by using a lights-out management (LOM) interface.
6. Boot the RHCOS ISO image without specifying any options or interrupting the live boot sequence. Wait for the installer to boot into a shell prompt in the RHCOS live environment.

NOTE

It is possible to interrupt the RHCOS installation boot process to add kernel arguments. However, for this ISO procedure you should use the **coreos-installer** command as outlined in the following steps, instead of adding kernel arguments.

7. Run the **coreos-installer** command and specify the options that meet your installation requirements. At a minimum, you must specify the URL that points to the Ignition config file for the node type, and the device that you are installing to:

```
$ sudo coreos-installer install --ignition-url=http://<HTTP_server>/<node_type>.ign <device>
--ignition-hash=sha512-<digest> 1 2
```

1 1 You must run the **coreos-installer** command by using **sudo**, because the **core** user does not have the required root privileges to perform the installation.

2 The **--ignition-hash** option is required when the Ignition config file is obtained through an HTTP URL to validate the authenticity of the Ignition config file on the cluster node. **<digest>** is the Ignition config file SHA512 digest obtained in a preceding step.

NOTE

If you want to provide your Ignition config files through an HTTPS server that uses TLS, you can add the internal certificate authority (CA) to the system trust store before running **coreos-installer**.

The following example initializes a bootstrap node installation to the **/dev/sda** device. The Ignition config file for the bootstrap node is obtained from an HTTP web server with the IP address 192.168.1.2:

```
$ sudo coreos-installer install --ignition-
```

```
url=http://192.168.1.2:80/installation_directory/bootstrap.ign /dev/sda --ignition-hash=sha512-
a5a2d43879223273c9b60af66b44202a1d1248fc01cf156c46d4a79f552b6bad47bc8cc78ddf011
6e80c59d2ea9e32ba53bc807afbca581aa059311def2c3e3b
```

8. Monitor the progress of the RHCOS installation on the console of the machine.

IMPORTANT

Be sure that the installation is successful on each node before commencing with the OpenShift Container Platform installation. Observing the installation process can also help to determine the cause of RHCOS installation issues that might arise.

9. After RHCOS installs, you must reboot the system. During the system reboot, it applies the Ignition config file that you specified.

10. Check the console output to verify that Ignition ran.

Example command

```
Ignition: ran on 2022/03/14 14:48:33 UTC (this boot)
Ignition: user-provided config was applied
```

11. Continue to create the other machines for your cluster.

IMPORTANT

You must create the bootstrap and control plane machines at this time. If the control plane machines are not made schedulable, also create at least two compute machines before you install OpenShift Container Platform.

If the required network, DNS, and load balancer infrastructure are in place, the OpenShift Container Platform bootstrap process begins automatically after the RHCOS nodes have rebooted.

NOTE

RHCOS nodes do not include a default password for the **core** user. You can access the nodes by running **ssh core@<node>.<cluster_name>.<base_domain>** as a user with access to the SSH private key that is paired to the public key that you specified in your **install_config.yaml** file. OpenShift Container Platform 4 cluster nodes running RHCOS are immutable and rely on Operators to apply cluster changes. Accessing cluster nodes by using SSH is not recommended. However, when investigating installation issues, if the OpenShift Container Platform API is not available, or the kubelet is not properly functioning on a target node, SSH access might be required for debugging or disaster recovery.

11.3.14.2. Installing RHCOS by using PXE or iPXE booting

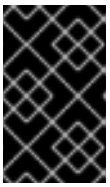
You can use PXE or iPXE booting to install RHCOS on the machines.

Prerequisites

- You have created the Ignition config files for your cluster.
- You have configured suitable network, DNS and load balancing infrastructure.
- You have configured suitable PXE or iPXE infrastructure.
- You have an HTTP server that can be accessed from your computer, and from the machines that you create.
- You have reviewed the *Advanced RHCOS installation configuration* section for different ways to configure features, such as networking and disk partitioning.

Procedure

1. Upload the bootstrap, control plane, and compute node Ignition config files that the installation program created to your HTTP server. Note the URLs of these files.



IMPORTANT

You can add or change configuration settings in your Ignition configs before saving them to your HTTP server. If you plan to add more compute machines to your cluster after you finish installation, do not delete these files.

2. From the installation host, validate that the Ignition config files are available on the URLs. The following example gets the Ignition config file for the bootstrap node:

```
$ curl -k http://<HTTP_server>/bootstrap.ign 1
```

Example output

```
  % Total    % Received % Xferd  Average Speed   Time    Time     Time  Current
                                 Dload  Upload   Total   Spent    Left  Speed
  0     0    0     0    0     0      0      0 --:--:-- --:--:-- --:--:--     0{"ignition":
{"version":"3.2.0"},"passwd":{"users":[{"name":"core","sshAuthorizedKeys":["ssh-rsa...
```

Replace **bootstrap.ign** with **master.ign** or **worker.ign** in the command to validate that the Ignition config files for the control plane and compute nodes are also available.

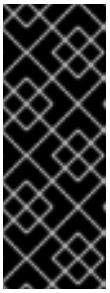
3. Although it is possible to obtain the RHCOS **kernel**, **initramfs** and **rootfs** files that are required for your preferred method of installing operating system instances from the RHCOS image mirror page, the recommended way to obtain the correct version of your RHCOS files are from the output of **openshift-install** command:

```
$ openshift-install coreos print-stream-json | grep -Eo '"https.*(kernel-|initramfs.|rootfs.)\w+
(\.img)?"'
```

Example output

```
"<url>/art/storage/releases/rhcos-4.11-aarch64/<release>/aarch64/rhcos-<release>-live-
kernel-aarch64"
"<url>/art/storage/releases/rhcos-4.11-aarch64/<release>/aarch64/rhcos-<release>-live-
initramfs.aarch64.img"
"<url>/art/storage/releases/rhcos-4.11-aarch64/<release>/aarch64/rhcos-<release>-live-
```

```
rootfs.aarch64.img"
"<url>/art/storage/releases/rhcos-4.11-ppc64le/49.84.202110081256-0/ppc64le/rhcos-
<release>-live-kernel-ppc64le"
"<url>/art/storage/releases/rhcos-4.11-ppc64le/<release>/ppc64le/rhcos-<release>-live-
initramfs.ppc64le.img"
"<url>/art/storage/releases/rhcos-4.11-ppc64le/<release>/ppc64le/rhcos-<release>-live-
rootfs.ppc64le.img"
"<url>/art/storage/releases/rhcos-4.11-s390x/<release>/s390x/rhcos-<release>-live-kernel-
s390x"
"<url>/art/storage/releases/rhcos-4.11-s390x/<release>/s390x/rhcos-<release>-live-
initramfs.s390x.img"
"<url>/art/storage/releases/rhcos-4.11-s390x/<release>/s390x/rhcos-<release>-live-
rootfs.s390x.img"
"<url>/art/storage/releases/rhcos-4.11/<release>/x86_64/rhcos-<release>-live-kernel-
x86_64"
"<url>/art/storage/releases/rhcos-4.11/<release>/x86_64/rhcos-<release>-live-
initramfs.x86_64.img"
"<url>/art/storage/releases/rhcos-4.11/<release>/x86_64/rhcos-<release>-live-
rootfs.x86_64.img"
```



IMPORTANT

The RHCOS artifacts might not change with every release of OpenShift Container Platform. You must download images with the highest version that is less than or equal to the OpenShift Container Platform version that you install. Only use the appropriate **kernel**, **initramfs**, and **rootfs** artifacts described below for this procedure. RHCOS QCOW2 images are not supported for this installation type.

The file names contain the OpenShift Container Platform version number. They resemble the following examples:

- **kernel**: **rhcos-<version>-live-kernel-<architecture>**
- **initramfs**: **rhcos-<version>-live-initramfs.<architecture>.img**
- **rootfs**: **rhcos-<version>-live-rootfs.<architecture>.img**

4. Upload the **rootfs**, **kernel**, and **initramfs** files to your HTTP server.

IMPORTANT

If you plan to add more compute machines to your cluster after you finish installation, do not delete these files.

5. Configure the network boot infrastructure so that the machines boot from their local disks after RHCOS is installed on them.

6. Configure PXE or iPXE installation for the RHCOS images and begin the installation.
Modify one of the following example menu entries for your environment and verify that the image and Ignition files are properly accessible:

   - For PXE (**x86_64**):

```
DEFAULT pxeboot
TIMEOUT 20
PROMPT 0
LABEL pxeboot
    KERNEL http://<HTTP_server>/rhcos-<version>-live-kernel-<architecture> 1
    APPEND initrd=http://<HTTP_server>/rhcos-<version>-live-initramfs.
<architecture>.img coreos.live.rootfs_url=http://<HTTP_server>/rhcos-<version>-live-
rootfs.<architecture>.img coreos.inst.install_dev=/dev/sda
coreos.inst.ignition_url=http://<HTTP_server>/bootstrap.ign 2 3
```

1 1 Specify the location of the live **kernel** file that you uploaded to your HTTP server. The URL must be HTTP, TFTP, or FTP; HTTPS and NFS are not supported.

2 If you use multiple NICs, specify a single interface in the **ip** option. For example, to use DHCP on a NIC that is named **eno1**, set **ip=eno1:dhcp**.

3 Specify the locations of the RHCOS files that you uploaded to your HTTP server. The **initrd** parameter value is the location of the **initramfs** file, the **coreos.live.rootfs_url** parameter value is the location of the **rootfs** file, and the **coreos.inst.ignition_url** parameter value is the location of the bootstrap Ignition config file. You can also add more kernel arguments to the **APPEND** line to configure networking or other boot options.

NOTE

This configuration does not enable serial console access on machines with a graphical console. To configure a different console, add one or more **console=** arguments to the **APPEND** line. For example, add **console=tty0 console=ttyS0** to set the first PC serial port as the primary console and the graphical console as a secondary console. For more information, see How does one set up a serial terminal and/or console in Red Hat Enterprise Linux?.

- For iPXE (**x86_64** + **aarch64**):

```
kernel http://<HTTP_server>/rhcos-<version>-live-kernel-<architecture> initrd=main
coreos.live.rootfs_url=http://<HTTP_server>/rhcos-<version>-live-rootfs.
<architecture>.img coreos.inst.install_dev=/dev/sda
coreos.inst.ignition_url=http://<HTTP_server>/bootstrap.ign 1 2
initrd --name main http://<HTTP_server>/rhcos-<version>-live-initramfs.
<architecture>.img 3
boot
```

1 Specify the locations of the RHCOS files that you uploaded to your HTTP server. The **kernel** parameter value is the location of the **kernel** file, the **initrd=main** argument is needed for booting on UEFI systems, the **coreos.live.rootfs_url** parameter value is the location of the **rootfs** file, and the **coreos.inst.ignition_url** parameter value is the location of the bootstrap Ignition config file.

2 If you use multiple NICs, specify a single interface in the **ip** option. For example, to use DHCP on a NIC that is named **eno1**, set **ip=eno1:dhcp**.

3 Specify the location of the **initramfs** file that you uploaded to your HTTP server.

NOTE

This configuration does not enable serial console access on machines with a graphical console. To configure a different console, add one or more **console=** arguments to the **kernel** line. For example, add **console=tty0 console=ttyS0** to set the first PC serial port as the primary console and the graphical console as a secondary console. For more information, see How does one set up a serial terminal and/or console in Red Hat Enterprise Linux?.

NOTE

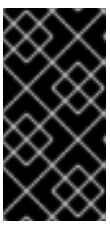
To network boot the CoreOS **kernel** on **aarch64** architecture, you need to use a version of iPXE build with the **IMAGE_GZIP** option enabled. See **IMAGE_GZIP** option in iPXE .

- For PXE (with UEFI and Grub as second stage) on **aarch64**:

```
menuentry 'Install CoreOS' {
    linux rhcos-<version>-live-kernel-<architecture>
coreos.live.rootfs_url=http://<HTTP_server>/rhcos-<version>-live-rootfs.
<architecture>.img coreos.inst.install_dev=/dev/sda
coreos.inst.ignition_url=http://<HTTP_server>/bootstrap.ign 1 2
    initrd rhcos-<version>-live-initramfs.<architecture>.img 3
}
```

1. Specify the locations of the RHCOS files that you uploaded to your HTTP/TFTP server. The **kernel** parameter value is the location of the **kernel** file on your TFTP server. The **coreos.live.rootfs_url** parameter value is the location of the **rootfs** file, and the **coreos.inst.ignition_url** parameter value is the location of the bootstrap Ignition config file on your HTTP Server.
2. If you use multiple NICs, specify a single interface in the **ip** option. For example, to use DHCP on a NIC that is named **eno1**, set **ip=eno1:dhcp**.
3. Specify the location of the **initramfs** file that you uploaded to your TFTP server.

7. Monitor the progress of the RHCOS installation on the console of the machine.



IMPORTANT

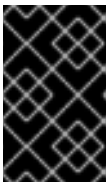
Be sure that the installation is successful on each node before commencing with the OpenShift Container Platform installation. Observing the installation process can also help to determine the cause of RHCOS installation issues that might arise.

8. After RHCOS installs, the system reboots. During reboot, the system applies the Ignition config file that you specified.
9. Check the console output to verify that Ignition ran.

Example command

```
Ignition: ran on 2022/03/14 14:48:33 UTC (this boot)
Ignition: user-provided config was applied
```

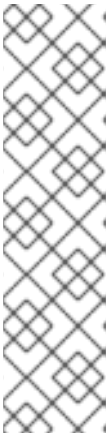
10. Continue to create the machines for your cluster.



IMPORTANT

You must create the bootstrap and control plane machines at this time. If the control plane machines are not made schedulable, also create at least two compute machines before you install the cluster.

If the required network, DNS, and load balancer infrastructure are in place, the OpenShift Container Platform bootstrap process begins automatically after the RHCOS nodes have rebooted.



NOTE

RHCOS nodes do not include a default password for the **core** user. You can access the nodes by running **ssh core@<node>.<cluster_name>.<base_domain>** as a user with access to the SSH private key that is paired to the public key that you specified in your **install_config.yaml** file. OpenShift Container Platform 4 cluster nodes running RHCOS are immutable and rely on Operators to apply cluster changes. Accessing cluster nodes by using SSH is not recommended. However, when investigating installation issues, if the OpenShift Container Platform API is not available, or the kubelet is not properly functioning on a target node, SSH access might be required for debugging or disaster recovery.

11.3.14.3. Advanced RHCOS installation configuration

A key benefit for manually provisioning the Red Hat Enterprise Linux CoreOS (RHCOS) nodes for OpenShift Container Platform is to be able to do configuration that is not available through default OpenShift Container Platform installation methods. This section describes some of the configurations that you can do using techniques that include:

- Passing kernel arguments to the live installer
- Running **coreos-installer** manually from the live system
- Customizing a live ISO or PXE boot image

The advanced configuration topics for manual Red Hat Enterprise Linux CoreOS (RHCOS) installations detailed in this section relate to disk partitioning, networking, and using Ignition configs in different ways.

11.3.14.3.1. Using advanced networking options for PXE and ISO installations

Networking for OpenShift Container Platform nodes uses DHCP by default to gather all necessary configuration settings. To set up static IP addresses or configure special settings, such as bonding, you can do one of the following:

- Pass special kernel parameters when you boot the live installer.
- Use a machine config to copy networking files to the installed system.

- Configure networking from a live installer shell prompt, then copy those settings to the installed system so that they take effect when the installed system first boots.

To configure a PXE or iPXE installation, use one of the following options:

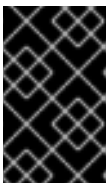
- See the "Advanced RHCOS installation reference" tables.
- Use a machine config to copy networking files to the installed system.

To configure an ISO installation, use the following procedure.

Procedure

1. Boot the ISO installer.
2. From the live system shell prompt, configure networking for the live system using available RHEL tools, such as **nmcli** or **nmtui**.
3. Run the **coreos-installer** command to install the system, adding the **--copy-network** option to copy networking configuration. For example:

```
$ sudo coreos-installer install --copy-network \
    --ignition-url=http://host/worker.ign /dev/sda
```



IMPORTANT

The **--copy-network** option only copies networking configuration found under **/etc/NetworkManager/system-connections**. In particular, it does not copy the system hostname.

4. Reboot into the installed system.

Additional resources

- See Getting started with nmcli and Getting started with nmtui in the RHEL 8 documentation for more information about the **nmcli** and **nmtui** tools.

11.3.14.3.2. Disk partitioning

The disk partitions are created on OpenShift Container Platform cluster nodes during the Red Hat Enterprise Linux CoreOS (RHCOS) installation. Each RHCOS node of a particular architecture uses the same partition layout, unless the default partitioning configuration is overridden. During the RHCOS installation, the size of the root file system is increased to use the remaining available space on the target device.

There are two cases where you might want to override the default partitioning when installing RHCOS on an OpenShift Container Platform cluster node:

- Creating separate partitions: For greenfield installations on an empty disk, you might want to add separate storage to a partition. This is officially supported for mounting **/var** or a subdirectory of **/var**, such as **/var/lib/etcd**, on a separate partition, but not both.

IMPORTANT

For disk sizes larger than 100GB, and especially disk sizes larger than 1TB, create a separate **/var** partition. See "Creating a separate **/var** partition" and this Red Hat Knowledgebase article for more information.

IMPORTANT

Kubernetes supports only two file system partitions. If you add more than one partition to the original configuration, Kubernetes cannot monitor all of them.

- Retaining existing partitions: For a brownfield installation where you are reinstalling OpenShift Container Platform on an existing node and want to retain data partitions installed from your previous operating system, there are both boot arguments and options to **coreos-installer** that allow you to retain existing data partitions.

WARNING

The use of custom partitions could result in those partitions not being monitored by OpenShift Container Platform or alerted on. If you are overriding the default partitioning, see Understanding OpenShift File System Monitoring (eviction conditions) for more information about how OpenShift Container Platform monitors your host file systems.

11.3.14.3.2.1. Creating a separate /var partition

In general, you should use the default disk partitioning that is created during the RHCOS installation. However, there are cases where you might want to create a separate partition for a directory that you expect to grow.

OpenShift Container Platform supports the addition of a single partition to attach storage to either the **/var** directory or a subdirectory of **/var**. For example:

- **/var/lib/containers**: Holds container-related content that can grow as more images and containers are added to a system.
- **/var/lib/etcd**: Holds data that you might want to keep separate for purposes such as performance optimization of etcd storage.
- **/var**: Holds data that you might want to keep separate for purposes such as auditing.

IMPORTANT

For disk sizes larger than 100GB, and especially larger than 1TB, create a separate **/var** partition.

Storing the contents of a **/var** directory separately makes it easier to grow storage for those areas as needed and reinstall OpenShift Container Platform at a later date and keep that data intact. With this method, you will not have to pull all your containers again, nor will you have to copy massive log files when you update systems.

The use of a separate partition for the /**var** directory or a subdirectory of /**var** also prevents data growth in the partitioned directory from filling up the root file system.

The following procedure sets up a separate /**var** partition by adding a machine config manifest that is wrapped into the Ignition config file for a node type during the preparation phase of an installation.

Procedure

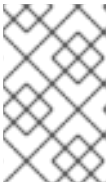
1. On your installation host, change to the directory that contains the OpenShift Container Platform installation program and generate the Kubernetes manifests for the cluster:

```
$ openshift-install create manifests --dir <installation_directory>
```

2. Create a Butane config that configures the additional partition. For example, name the file **$HOME/clusterconfig/98-var-partition.bu**, change the disk device name to the name of the storage device on the **worker** systems, and set the storage size as appropriate. This example places the /**var** directory on a separate partition:

```
variant: openshift
version: 4.11.0
metadata:
  labels:
    machineconfiguration.openshift.io/role: worker
  name: 98-var-partition
storage:
  disks:
  - device: /dev/<device_name> 1
    partitions:
    - label: var
      start_mib: <partition_start_offset> 2
      size_mib: <partition_size> 3
  filesystems:
    - device: /dev/disk/by-partlabel/var
      path: /var
      format: xfs
      mount_options: [defaults, prjquota] 4
      with_mount_unit: true
```

1. The storage device name of the disk that you want to partition.
2. When adding a data partition to the boot disk, a minimum offset value of 25000 mebibytes is recommended. The root file system is automatically resized to fill all available space up to the specified offset. If no offset value is specified, or if the specified value is smaller than the recommended minimum, the resulting root file system will be too small, and future reinstalls of RHCOS might overwrite the beginning of the data partition.
3. The size of the data partition in mebibytes.
4. The **prjquota** mount option must be enabled for filesystems used for container storage.



NOTE

When creating a separate /**var** partition, you cannot use different instance types for compute nodes, if the different instance types do not have the same device name.

3. Create a manifest from the Butane config and save it to the **clusterconfig/openshift** directory. For example, run the following command:

```
$ butane $HOME/clusterconfig/98-var-partition.bu -o $HOME/clusterconfig/openshift/98-var-partition.yaml
```

4. Create the Ignition config files:

```
$ openshift-install create ignition-configs --dir <installation_directory> 1
```

1 For **<installation_directory>**, specify the same installation directory.

Ignition config files are created for the bootstrap, control plane, and compute nodes in the installation directory:

```
.
├── auth
│   ├── kubeadmin-password
│   └── kubeconfig
├── bootstrap.ign
├── master.ign
├── metadata.json
└── worker.ign
```

The files in the **<installation_directory>/manifest** and **<installation_directory>/openshift** directories are wrapped into the Ignition config files, including the file that contains the **98-var-partition** custom **MachineConfig** object.

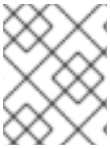
Next steps

- You can apply the custom disk partitioning by referencing the Ignition config files during the RHCOS installations.

11.3.14.3.2.2. Retaining existing partitions

For an ISO installation, you can add options to the **coreos-installer** command that cause the installer to maintain one or more existing partitions. For a PXE installation, you can add **coreos.inst.*** options to the **APPEND** parameter to preserve partitions.

Saved partitions might be data partitions from an existing OpenShift Container Platform system. You can identify the disk partitions you want to keep either by partition label or by number.



NOTE

If you save existing partitions, and those partitions do not leave enough space for RHCOS, the installation will fail without damaging the saved partitions.

Retaining existing partitions during an ISO installation

This example preserves any partition in which the partition label begins with **data** (**data***):

```
# coreos-installer install --ignition-url http://10.0.2.2:8080/user.ign \
      --save-partlabel 'data*' /dev/sda
```

The following example illustrates running the **coreos-installer** in a way that preserves the sixth (6) partition on the disk:

```
# coreos-installer install --ignition-url http://10.0.2.2:8080/user.ign \
      --save-partindex 6 /dev/sda
```

This example preserves partitions 5 and higher:

```
# coreos-installer install --ignition-url http://10.0.2.2:8080/user.ign
      --save-partindex 5- /dev/sda
```

In the previous examples where partition saving is used, **coreos-installer** recreates the partition immediately.

Retaining existing partitions during a PXE installation

This **APPEND** option preserves any partition in which the partition label begins with 'data' ('data*'):

```
coreos.inst.save_partlabel=data*
```

This **APPEND** option preserves partitions 5 and higher:

```
coreos.inst.save_partindex=5-
```

This **APPEND** option preserves partition 6:

```
coreos.inst.save_partindex=6
```

11.3.14.3.3. Identifying Ignition configs

When doing an RHCOS manual installation, there are two types of Ignition configs that you can provide, with different reasons for providing each one:

- **Permanent install Ignition config**: Every manual RHCOS installation needs to pass one of the Ignition config files generated by **openshift-installer**, such as **bootstrap.ign**, **master.ign** and **worker.ign**, to carry out the installation.

  IMPORTANT

  It is not recommended to modify these Ignition config files directly. You can update the manifest files that are wrapped into the Ignition config files, as outlined in examples in the preceding sections.

  For PXE installations, you pass the Ignition configs on the **APPEND** line using the **coreos.inst.ignition_url=** option. For ISO installations, after the ISO boots to the shell prompt, you identify the Ignition config on the **coreos-installer** command line with the **--ignition-url=**

option. In both cases, only HTTP and HTTPS protocols are supported.

- **Live install Ignition config**: This type can be created by using the **coreos-installer customize** subcommand and its various options. With this method, the Ignition config passes to the live install medium, runs immediately upon booting, and performs setup tasks before or after the RHCOS system installs to disk. This method should only be used for performing tasks that must be done once and not applied again later, such as with advanced partitioning that cannot be done using a machine config.
  For PXE or ISO boots, you can create the Ignition config and **APPEND** the **ignition.config.url=** option to identify the location of the Ignition config. You also need to append **ignition.firstboot ignition.platform.id=metal** or the **ignition.config.url** option will be ignored.

11.3.14.3.3.1. Customizing a live RHCOS ISO or PXE install

You can use the live ISO image or PXE environment to install RHCOS by injecting an Ignition config file directly into the image. This creates a customized image that you can use to provision your system.

For an ISO image, the mechanism to do this is the **coreos-installer iso customize** subcommand, which modifies the **.iso** file with your configuration. Similarly, the mechanism for a PXE environment is the **coreos-installer pxe customize** subcommand, which creates a new **initramfs** file that includes your customizations.

The **customize** subcommand is a general purpose tool that can embed other types of customizations as well. The following tasks are examples of some of the more common customizations:

- Inject custom CA certificates for when corporate security policy requires their use.
- Configure network settings without the need for kernel arguments.
- Embed arbitrary preinstall and post-install scripts or binaries.

11.3.14.3.3.2. Customizing a live RHCOS ISO image

You can customize a live RHCOS ISO image directly with the **coreos-installer iso customize** subcommand. When you boot the ISO image, the customizations are applied automatically.

You can use this feature to configure the ISO image to automatically install RHCOS.

Procedure

1. Download the **coreos-installer** binary from the **coreos-installer** image mirror page.
2. Retrieve the RHCOS ISO image from the RHCOS image mirror page and the Ignition config file, and then run the following command to inject the Ignition config directly into the ISO image:

```
$ coreos-installer iso customize rhcos-<version>-live.x86_64.iso \
    --dest-ignition bootstrap.ign \ 1
    --dest-device /dev/sda 2
```

1. The Ignition config file that is generated from the **openshift-installer** installation program.
2. When you specify this option, the ISO image automatically runs an installation. Otherwise, the image remains configured for installation, but does not install automatically unless you specify the **coreos.inst.install_dev** kernel argument.

3. Optional: To remove the ISO image customizations and return the image to its pristine state, run:

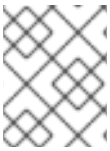
```
$ coreos-installer iso reset rhcos-<version>-live.x86_64.iso
```

You can now re-customize the live ISO image or use it in its pristine state.

Applying your customizations affects every subsequent boot of RHCOS.

11.3.14.3.3.2.1. Modifying a live install ISO image to use a custom certificate authority

You can provide certificate authority (CA) certificates to Ignition with the **--ignition-ca** flag of the **customize** subcommand. You can use the CA certificates during both the installation boot and when provisioning the installed system.



NOTE

Custom CA certificates affect how Ignition fetches remote resources but they do not affect the certificates installed onto the system.

Procedure

1. Download the **coreos-installer** binary from the **coreos-installer** image mirror page.
2. Retrieve the RHCOS ISO image from the RHCOS image mirror page and run the following command to customize the ISO image for use with a custom CA:

```
$ coreos-installer iso customize rhcos-<version>-live.x86_64.iso --ignition-ca cert.pem
```

IMPORTANT

The **coreos.inst.ignition_url** kernel parameter does not work with the **--ignition-ca** flag. You must use the **--dest-ignition** flag to create a customized image for each cluster.

Applying your custom CA certificate affects every subsequent boot of RHCOS.

11.3.14.3.3.2.2. Modifying a live install ISO image with customized network settings

You can embed a NetworkManager keyfile into the live ISO image and pass it through to the installed system with the **--network-keyfile** flag of the **customize** subcommand.

WARNING

When creating a connection profile, you must use a **.nmconnection** filename extension in the filename of the connection profile. If you do not use a **.nmconnection** filename extension, the cluster will apply the connection profile to the live environment, but it will not apply the configuration when the cluster first boots up the nodes, resulting in a setup that does not work.

Procedure

1. Download the **coreos-installer** binary from the **coreos-installer** image mirror page.

2. Create a connection profile for a bonded interface. For example, create the **bond0.nmconnection** file in your local directory with the following content:

```
[connection]
id=bond0
type=bond
interface-name=bond0
multi-connect=1
permissions=

[ethernet]
mac-address-blacklist=

[bond]
miimon=100
mode=active-backup

[ipv4]
method=auto

[ipv6]
method=auto

[proxy]
```

3. Create a connection profile for a secondary interface to add to the bond. For example, create the **bond0-proxy-em1.nmconnection** file in your local directory with the following content:

```
[connection]
id=em1
type=ethernet
interface-name=em1
master=bond0
multi-connect=1
permissions=
slave-type=bond

[ethernet]
mac-address-blacklist=
```

4. Create a connection profile for a secondary interface to add to the bond. For example, create the **bond0-proxy-em2.nmconnection** file in your local directory with the following content:

```
[connection]
id=em2
type=ethernet
interface-name=em2
master=bond0
multi-connect=1
permissions=
slave-type=bond
```

```
[ethernet]
mac-address-blacklist=
```

5. Retrieve the RHCOS ISO image from the RHCOS image mirror page and run the following command to customize the ISO image with your configured networking:

```
$ coreos-installer iso customize rhcos-<version>-live.x86_64.iso \
    --network-keyfile bond0.nmconnection \
    --network-keyfile bond0-proxy-em1.nmconnection \
    --network-keyfile bond0-proxy-em2.nmconnection
```

Network settings are applied to the live system and are carried over to the destination system.

11.3.14.3.3.3. Customizing a live RHCOS PXE environment

You can customize a live RHCOS PXE environment directly with the **coreos-installer pxe customize** subcommand. When you boot the PXE environment, the customizations are applied automatically.

You can use this feature to configure the PXE environment to automatically install RHCOS.

Procedure

1. Download the **coreos-installer** binary from the **coreos-installer** image mirror page.
2. Retrieve the RHCOS **kernel**, **initramfs** and **rootfs** files from the RHCOS image mirror page and the Ignition config file, and then run the following command to create a new **initramfs** file that contains the customizations from your Ignition config:

```
$ coreos-installer pxe customize rhcos-<version>-live-initramfs.x86_64.img \
    --dest-ignition bootstrap.ign \ 1
    --dest-device /dev/sda \ 2
    -o rhcos-<version>-custom-initramfs.x86_64.img 3
```

1. The Ignition config file that is generated from **openshift-installer**.
2. When you specify this option, the PXE environment automatically runs an install. Otherwise, the image remains configured for installing, but does not do so automatically unless you specify the **coreos.inst.install_dev** kernel argument.
3. Use the customized **initramfs** file in your PXE configuration. Add the **ignition.firstboot** and **ignition.platform.id=metal** kernel arguments if they are not already present.

Applying your customizations affects every subsequent boot of RHCOS.

11.3.14.3.3.3.1. Modifying a live install PXE environment to use a custom certificate authority

You can provide certificate authority (CA) certificates to Ignition with the **--ignition-ca** flag of the **customize** subcommand. You can use the CA certificates during both the installation boot and when provisioning the installed system.

NOTE

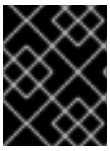
Custom CA certificates affect how Ignition fetches remote resources but they do not affect the certificates installed onto the system.

Procedure

1. Download the **coreos-installer** binary from the **coreos-installer** image mirror page.
2. Retrieve the RHCOS **kernel**, **initramfs** and **rootfs** files from the RHCOS image mirror page and run the following command to create a new customized **initramfs** file for use with a custom CA:

```
$ coreos-installer pxe customize rhcos-<version>-live-initramfs.x86_64.img \
    --ignition-ca cert.pem \
    -o rhcos-<version>-custom-initramfs.x86_64.img
```

3. Use the customized **initramfs** file in your PXE configuration. Add the **ignition.firstboot** and **ignition.platform.id=metal** kernel arguments if they are not already present.



IMPORTANT

The **coreos.inst.ignition_url** kernel parameter does not work with the **--ignition-ca** flag. You must use the **--dest-ignition** flag to create a customized image for each cluster.

Applying your custom CA certificate affects every subsequent boot of RHCOS.

11.3.14.3.3.3.2. Modifying a live install PXE environment with customized network settings

You can embed a NetworkManager keyfile into the live PXE environment and pass it through to the installed system with the **--network-keyfile** flag of the **customize** subcommand.

WARNING

When creating a connection profile, you must use a **.nmconnection** filename extension in the filename of the connection profile. If you do not use a **.nmconnection** filename extension, the cluster will apply the connection profile to the live environment, but it will not apply the configuration when the cluster first boots up the nodes, resulting in a setup that does not work.

Procedure

1. Download the **coreos-installer** binary from the **coreos-installer** image mirror page.
2. Create a connection profile for a bonded interface. For example, create the **bond0.nmconnection** file in your local directory with the following content:

```
[connection]
id=bond0
type=bond
interface-name=bond0
```

```
multi-connect=1
permissions=

[ethernet]
mac-address-blacklist=

[bond]
miimon=100
mode=active-backup

[ipv4]
method=auto

[ipv6]
method=auto

[proxy]
```

3. Create a connection profile for a secondary interface to add to the bond. For example, create the **bond0-proxy-em1.nmconnection** file in your local directory with the following content:

```
[connection]
id=em1
type=ethernet
interface-name=em1
master=bond0
multi-connect=1
permissions=
slave-type=bond

[ethernet]
mac-address-blacklist=
```

4. Create a connection profile for a secondary interface to add to the bond. For example, create the **bond0-proxy-em2.nmconnection** file in your local directory with the following content:

```
[connection]
id=em2
type=ethernet
interface-name=em2
master=bond0
multi-connect=1
permissions=
slave-type=bond

[ethernet]
mac-address-blacklist=
```

5. Retrieve the RHCOS **kernel**, **initramfs** and **rootfs** files from the RHCOS image mirror page and run the following command to create a new customized **initramfs** file that contains your configured networking:

```
$ coreos-installer pxe customize rhcos-<version>-live-initramfs.x86_64.img \
    --network-keyfile bond0.nmconnection \
    --network-keyfile bond0-proxy-em1.nmconnection \
```

```
--network-keyfile bond0-proxy-em2.nmconnection \
-o rhcos-<version>-custom-initramfs.x86_64.img
```

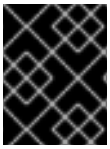
6. Use the customized **initramfs** file in your PXE configuration. Add the **ignition.firstboot** and **ignition.platform.id=metal** kernel arguments if they are not already present.
Network settings are applied to the live system and are carried over to the destination system.

11.3.14.3.4. Advanced RHCOS installation reference

This section illustrates the networking configuration and other advanced options that allow you to modify the Red Hat Enterprise Linux CoreOS (RHCOS) manual installation process. The following tables describe the kernel arguments and command-line options you can use with the RHCOS live installer and the **coreos-installer** command.

11.3.14.3.4.1. Networking and bonding options for ISO installations

If you install RHCOS from an ISO image, you can add kernel arguments manually when you boot the image to configure networking for a node. If no networking arguments are specified, DHCP is activated in the initramfs when RHCOS detects that networking is required to fetch the Ignition config file.



IMPORTANT

When adding networking arguments manually, you must also add the **rd.neednet=1** kernel argument to bring the network up in the initramfs.

The following information provides examples for configuring networking and bonding on your RHCOS nodes for ISO installations. The examples describe how to use the **ip=**, **nameserver=**, and **bond=** kernel arguments.

NOTE

Ordering is important when adding the kernel arguments: **ip=**, **nameserver=**, and then **bond=**.

The networking options are passed to the **dracut** tool during system boot. For more information about the networking options supported by **dracut**, see the **dracut.cmdline** manual page.

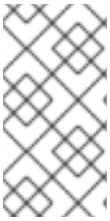
The following examples are the networking options for ISO installation.

Configuring DHCP or static IP addresses
To configure an IP address, either use DHCP (**ip=dhcp**) or set an individual static IP address (**ip=<host_ip>**). If setting a static IP, you must then identify the DNS server IP address (**nameserver=<dns_ip>**) on each node. The following example sets:

- The node's IP address to **10.10.10.2**
- The gateway address to **10.10.10.254**
- The netmask to **255.255.255.0**
- The hostname to **core0.example.com**
- The DNS server address to **4.4.4.41**

- The auto-configuration value to **none**. No auto-configuration is required when IP networking is configured statically.

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp1s0:none
nameserver=4.4.4.41
```



NOTE

When you use DHCP to configure IP addressing for the RHCOS machines, the machines also obtain the DNS server information through DHCP. For DHCP-based deployments, you can define the DNS server address that is used by the RHCOS nodes through your DHCP server configuration.

Configuring an IP address without a static hostname
You can configure an IP address without assigning a static hostname. If a static hostname is not set by the user, it will be picked up and automatically set by a reverse DNS lookup. To configure an IP address without a static hostname refer to the following example:

- The node's IP address to **10.10.10.2**
- The gateway address to **10.10.10.254**
- The netmask to **255.255.255.0**
- The DNS server address to **4.4.4.41**
- The auto-configuration value to **none**. No auto-configuration is required when IP networking is configured statically.

```
ip=10.10.10.2::10.10.10.254:255.255.255.0::enp1s0:none
nameserver=4.4.4.41
```

Specifying multiple network interfaces
You can specify multiple network interfaces by setting multiple **ip=** entries.

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp1s0:none
ip=10.10.10.3::10.10.10.254:255.255.255.0:core0.example.com:enp2s0:none
```

Configuring default gateway and route
Optional: You can configure routes to additional networks by setting an **rd.route=** value.

NOTE

When you configure one or multiple networks, one default gateway is required. If the additional network gateway is different from the primary network gateway, the default gateway must be the primary network gateway.

- Run the following command to configure the default gateway:

```
ip=::10.10.10.254::::
```

- Enter the following command to configure the route for the additional network:

```
rd.route=20.20.20.0/24:20.20.20.254:enp2s0
```

Disabling DHCP on a single interface
You can disable DHCP on a single interface, such as when there are two or more network interfaces and only one interface is being used. In the example, the **enp1s0** interface has a static networking configuration and DHCP is disabled for **enp2s0**, which is not used:

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp1s0:none
ip=::::core0.example.com:enp2s0:none
```

Combining DHCP and static IP configurations
You can combine DHCP and static IP configurations on systems with multiple network interfaces, for example:

```
ip=enp1s0:dhcp
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp2s0:none
```

Configuring VLANs on individual interfaces
Optional: You can configure VLANs on individual interfaces by using the **vlan=** parameter.

- To configure a VLAN on a network interface and use a static IP address, run the following command:

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp2s0.100:none
vlan=enp2s0.100:enp2s0
```

- To configure a VLAN on a network interface and to use DHCP, run the following command:

```
ip=enp2s0.100:dhcp
vlan=enp2s0.100:enp2s0
```

Providing multiple DNS servers
You can provide multiple DNS servers by adding a **nameserver=** entry for each server, for example:

```
nameserver=1.1.1.1
nameserver=8.8.8.8
```

Bonding multiple network interfaces to a single interface
Optional: You can bond multiple network interfaces to a single interface by using the **bond=** option. Refer to the following examples:

- The syntax for configuring a bonded interface is: **bond=name[:network_interfaces][:options]** *name* is the bonding device name (**bond0**), *network_interfaces* represents a comma-separated list of physical (ethernet) interfaces (**em1,em2**), and *options* is a comma-separated list of bonding options. Enter **modinfo bonding** to see available options.

- When you create a bonded interface using **bond=**, you must specify how the IP address is assigned and other information for the bonded interface.

- To configure the bonded interface to use DHCP, set the bond's IP address to **dhcp**. For example:

```
bond=bond0:em1,em2:mode=active-backup
ip=bond0:dhcp
```

- To configure the bonded interface to use a static IP address, enter the specific IP address you want and related information. For example:

```
bond=bond0:em1,em2:mode=active-backup
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:bond0:none
```

Bonding multiple network interfaces to a single interface
Optional: You can configure VLANs on bonded interfaces by using the **vlan=** parameter and to use DHCP, for example:

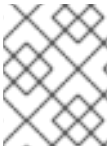
```
ip=bond0.100:dhcp
bond=bond0:em1,em2:mode=active-backup
vlan=bond0.100:bond0
```

Use the following example to configure the bonded interface with a VLAN and to use a static IP address:

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:bond0.100:none
bond=bond0:em1,em2:mode=active-backup
vlan=bond0.100:bond0
```

Using network teaming
Optional: You can use a network teaming as an alternative to bonding by using the **team=** parameter:

- The syntax for configuring a team interface is: **team=name[:network_interfaces]**
  name is the team device name (**team0**) and *network_interfaces* represents a comma-separated list of physical (ethernet) interfaces (**em1, em2**).



NOTE

Teaming is planned to be deprecated when RHCOS switches to an upcoming version of RHEL. For more information, see this Red Hat Knowledgebase Article .

Use the following example to configure a network team:

```
team=team0:em1,em2
ip=team0:dhcp
```

11.3.14.3.4.2. coreos-installer options for ISO and PXE installations

You can install RHCOS by running **coreos-installer install <options> <device>** at the command prompt, after booting into the RHCOS live environment from an ISO image.

The following table shows the subcommands, options, and arguments you can pass to the **coreos-installer** command.

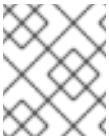
Table 11.32. coreos-installer subcommands, command-line options, and arguments

coreos-installer install subcommand

Subcommand	*Description*
$ coreos-installer install <options> <device>	Embed an Ignition config in an ISO image.
coreos-installer install subcommand options	
Option	*Description*
-u, **--image-url <url>**	Specify the image URL manually.
-f, **--image-file <path>**	Specify a local image file manually. Used for debugging.
-i, --ignition-file <path>	Embed an Ignition config from a file.
-I, **--ignition-url <URL>**	Embed an Ignition config from a URL.
--ignition-hash <digest>	Digest **type-value** of the Ignition config.
-p, **--platform <name>**	Override the Ignition platform ID for the installed system.
--append-karg <arg>…	Append a default kernel argument to the installed system.
--delete-karg <arg>…	Delete a default kernel argument from the installed system.
-n, **--copy-network**	Copy the network configuration from the install environment.  **IMPORTANT** The **--copy-network** option only copies networking configuration found under **/etc/NetworkManager/system-connections**. In particular, it does not copy the system hostname.
--network-dir <path>	For use with **-n**. Default is **/etc/NetworkManager/system-connections/**.
--save-partlabel <lx>..	Save partitions with this label glob.
--save-partindex <id>…	Save partitions with this number or range.
--insecure	Skip RHCOS image signature verification.

--insecure-ignition	Allow Ignition URL without HTTPS or hash.
--architecture <name>	Target CPU architecture. Valid values are **x86_64** and **aarch64**.
--preserve-on-error	Do not clear partition table on error.
-h, **--help**	Print help information.
coreos-installer install subcommand argument	
Argument	*Description*
<device>	The destination device.
coreos-installer ISO subcommands	
Subcommand	*Description*
$ coreos-installer iso customize <options> <ISO_image>	Customize a RHCOS live ISO image.
coreos-installer iso reset <options> <ISO_image>	Restore a RHCOS live ISO image to default settings.
coreos-installer iso ignition remove <options> <ISO_image>	Remove the embedded Ignition config from an ISO image.
coreos-installer ISO customize subcommand options	
Option	*Description*
--dest-ignition <path>	Merge the specified Ignition config file into a new configuration fragment for the destination system.
--dest-device <path>	Install and overwrite the specified destination device.
--dest-karg-append <arg>	Add a kernel argument to each boot of the destination system.
--dest-karg-delete <arg>	Delete a kernel argument from each boot of the destination system.
--network-keyfile <path>	Configure networking by using the specified NetworkManager keyfile for live and destination systems.

--ignition-ca <path>	Specify an additional TLS certificate authority to be trusted by Ignition.
--pre-install <path>	Run the specified script before installation.
--post-install <path>	Run the specified script after installation.
--installer-config <path>	Apply the specified installer configuration file.
--live-ignition <path>	Merge the specified Ignition config file into a new configuration fragment for the live environment.
--live-karg-append <arg>	Add a kernel argument to each boot of the live environment.
--live-karg-delete <arg>	Delete a kernel argument from each boot of the live environment.
--live-karg-replace <k=o=n>	Replace a kernel argument in each boot of the live environment, in the form **key=old=new**.
-f, **--force**	Overwrite an existing Ignition config.
-o, **--output <path>**	Write the ISO to a new output file.
-h, **--help**	Print help information.
coreos-installer PXE subcommands	
Subcommand	*Description*
Note that not all of these options are accepted by all subcommands.	
coreos-installer pxe customize <options> <path>	Customize a RHCOS live PXE boot config.
coreos-installer pxe ignition wrap <options>	Wrap an Ignition config in an image.
coreos-installer pxe ignition unwrap <options> <image_name>	Show the wrapped Ignition config in an image.
coreos-installer PXE customize subcommand options	
Option	*Description*
Note that not all of these options are accepted by all subcommands.	

--dest-ignition <path>	Merge the specified Ignition config file into a new configuration fragment for the destination system.
--dest-device <path>	Install and overwrite the specified destination device.
--network-keyfile <path>	Configure networking by using the specified NetworkManager keyfile for live and destination systems.
--ignition-ca <path>	Specify an additional TLS certificate authority to be trusted by Ignition.
--pre-install <path>	Run the specified script before installation.
post-install <path>	Run the specified script after installation.
--installer-config <path>	Apply the specified installer configuration file.
--live-ignition <path>	Merge the specified Ignition config file into a new configuration fragment for the live environment.
-o, --output <path>	Write the initramfs to a new output file.  NOTE This option is required for PXE environments.
-h, --help	Print help information.

11.3.14.3.4.3. **coreos.inst** boot options for ISO or PXE installations

You can automatically invoke **coreos-installer** options at boot time by passing **coreos.inst** boot arguments to the RHCOS live installer. These are provided in addition to the standard boot arguments.

- For ISO installations, the **coreos.inst** options can be added by interrupting the automatic boot at the bootloader menu. You can interrupt the automatic boot by pressing **TAB** while the **RHEL CoreOS (Live)** menu option is highlighted.
- For PXE or iPXE installations, the **coreos.inst** options must be added to the **APPEND** line before the RHCOS live installer is booted.

The following table shows the RHCOS live installer **coreos.inst** boot options for ISO and PXE installations.

Table 11.33. coreos.inst boot options

Argument	Description
coreos.inst.install_dev	Required. The block device on the system to install to. It is recommended to use the full path, such as **/dev/sda**, although **sda** is allowed.
coreos.inst.ignition_url	Optional: The URL of the Ignition config to embed into the installed system. If no URL is specified, no Ignition config is embedded. Only HTTP and HTTPS protocols are supported.
coreos.inst.save_partlabel	Optional: Comma-separated labels of partitions to preserve during the install. Glob-style wildcards are permitted. The specified partitions do not need to exist.
coreos.inst.save_partindex	Optional: Comma-separated indexes of partitions to preserve during the install. Ranges **m-n** are permitted, and either **m** or **n** can be omitted. The specified partitions do not need to exist.
coreos.inst.insecure	Optional: Permits the OS image that is specified by **coreos.inst.image_url** to be unsigned.
coreos.inst.image_url	Optional: Download and install the specified RHCOS image. • This argument should not be used in production environments and is intended for debugging purposes only. • While this argument can be used to install a version of RHCOS that does not match the live media, it is recommended that you instead use the media that matches the version you want to install. • If you are using **coreos.inst.image_url**, you must also use **coreos.inst.insecure**. This is because the bare-metal media are not GPG-signed for OpenShift Container Platform. • Only HTTP and HTTPS protocols are supported.
coreos.inst.skip_reboot	Optional: The system will not reboot after installing. After the install finishes, you will receive a prompt that allows you to inspect what is happening during installation. This argument should not be used in production environments and is intended for debugging purposes only.

Argument	Description
coreos.inst.platform_id	Optional: The Ignition platform ID of the platform the RHCOS image is being installed on. Default is **metal**. This option determines whether or not to request an Ignition config from the cloud provider, such as VMware. For example: **coreos.inst.platform_id=vmware**.
ignition.config.url	Optional: The URL of the Ignition config for the live boot. For example, this can be used to customize how **coreos-installer** is invoked, or to run code before or after the installation. This is different from **coreos.inst.ignition_url**, which is the Ignition config for the installed system.

11.3.14.4. Enabling multipathing with kernel arguments on RHCOS

RHCOS supports multipathing on the primary disk, allowing stronger resilience to hardware failure to achieve higher host availability.

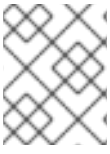
You can enable multipathing at installation time for nodes that were provisioned in OpenShift Container Platform 4.8 or later. While postinstallation support is available by activating multipathing via the machine config, enabling multipathing during installation is recommended.

In setups where any I/O to non-optimized paths results in I/O system errors, you must enable multipathing at installation time.

IMPORTANT

On IBM Z and LinuxONE, you can enable multipathing only if you configured your cluster for it during installation. For more information, see "Installing RHCOS and starting the OpenShift Container Platform bootstrap process" in *Installing a cluster with z/VM on IBM Z and LinuxONE*.

The following procedure enables multipath at installation time and appends kernel arguments to the **coreos-installer install** command so that the installed system itself will use multipath beginning from the first boot.



NOTE

OpenShift Container Platform does not support enabling multipathing as a day-2 activity on nodes that have been upgraded from 4.6 or earlier.

Procedure

1. To enable multipath and start the **multipathd** daemon, run the following command:

```
$ mpathconf --enable && systemctl start multipathd.service
```

- Optional: If booting the PXE or ISO, you can instead enable multipath by adding **rd.multipath=default** from the kernel command line.

2. Append the kernel arguments by invoking the **coreos-installer** program:

   - If there is only one multipath device connected to the machine, it should be available at path **/dev/mapper/mpatha**. For example:

     ```
     $ coreos-installer install /dev/mapper/mpatha \ 1
     --append-karg rd.multipath=default \
     --append-karg root=/dev/disk/by-label/dm-mpath-root \
     --append-karg rw
     ```

     1 Indicates the path of the single multipathed device.

   - If there are multiple multipath devices connected to the machine, or to be more explicit, instead of using **/dev/mapper/mpatha**, it is recommended to use the World Wide Name (WWN) symlink available in **/dev/disk/by-id**. For example:

     ```
     $ coreos-installer install /dev/disk/by-id/wwn-<wwn_ID> \ 1
     --append-karg rd.multipath=default \
     --append-karg root=/dev/disk/by-label/dm-mpath-root \
     --append-karg rw
     ```

     1 Indicates the WWN ID of the target multipathed device. For example, **0xx194e957fcedb4841**.

     This symlink can also be used as the **coreos.inst.install_dev** kernel argument when using special **coreos.inst.*** arguments to direct the live installer. For more information, see "Installing RHCOS and starting the OpenShift Container Platform bootstrap process".

3. Check that the kernel arguments worked by going to one of the worker nodes and listing the kernel command line arguments (in **/proc/cmdline** on the host):

   ```
   $ oc debug node/ip-10-0-141-105.ec2.internal
   ```

   Example output

   ```
   Starting pod/ip-10-0-141-105ec2internal-debug ...
   To use host binaries, run `chroot /host`

   sh-4.2# cat /host/proc/cmdline
   ...
   rd.multipath=default root=/dev/disk/by-label/dm-mpath-root
   ...

   sh-4.2# exit
   ```

   You should see the added kernel arguments.

11.3.14.5. Updating the bootloader using bootupd

To update the bootloader by using **bootupd**, you must either install **bootupd** on RHCOS machines

manually or provide a machine config with the enabled **systemd** unit. Unlike **grubby** or other bootloader tools, **bootupd** does not manage kernel space configuration such as passing kernel arguments.

After you have installed **bootupd**, you can manage it remotely from the OpenShift Container Platform cluster.

NOTE

It is recommended that you use **bootupd** only on bare metal or virtualized hypervisor installations, such as for protection against the BootHole vulnerability.

Manual install method

You can manually install **bootupd** by using the **bootctl** command-line tool.

1. Inspect the system status:

```
# bootupctl status
```

Example output for x86_64

```
Component EFI
  Installed: grub2-efi-x64-1:2.04-31.fc33.x86_64,shim-x64-15-8.x86_64
  Update: At latest version
```

Example output for aarch64

```
Component EFI
  Installed: grub2-efi-aa64-1:2.02-99.el8_4.1.aarch64,shim-aa64-15.4-2.el8_1.aarch64
  Update: At latest version
```

2. RHCOS images created without **bootupd** installed on them require an explicit adoption phase. If the system status is **Adoptable**, perform the adoption:

```
# bootupctl adopt-and-update
```

Example output

```
Updated: grub2-efi-x64-1:2.04-31.fc33.x86_64,shim-x64-15-8.x86_64
```

3. If an update is available, apply the update so that the changes take effect on the next reboot:

```
# bootupctl update
```

Example output

```
Updated: grub2-efi-x64-1:2.04-31.fc33.x86_64,shim-x64-15-8.x86_64
```

Machine config method

Another way to enable **bootupd** is by providing a machine config.

- Provide a machine config file with the enabled **systemd** unit, as shown in the following example:

  Example output

```
variant: rhcos
version: 1.1.0
systemd:
  units:
    - name: custom-bootupd-auto.service
      enabled: true
      contents: |
        [Unit]
        Description=Bootupd automatic update

        [Service]
        ExecStart=/usr/bin/bootupctl update
        RemainAfterExit=yes

        [Install]
        WantedBy=multi-user.target
```

11.3.15. Waiting for the bootstrap process to complete

The OpenShift Container Platform bootstrap process begins after the cluster nodes first boot into the persistent RHCOS environment that has been installed to disk. The configuration information provided through the Ignition config files is used to initialize the bootstrap process and install OpenShift Container Platform on the machines. You must wait for the bootstrap process to complete.

Prerequisites

- You have created the Ignition config files for your cluster.
- You have configured suitable network, DNS and load balancing infrastructure.
- You have obtained the installation program and generated the Ignition config files for your cluster.
- You installed RHCOS on your cluster machines and provided the Ignition config files that the OpenShift Container Platform installation program generated.
- Your machines have direct internet access or have an HTTP or HTTPS proxy available.

Procedure

1. Monitor the bootstrap process:

```
$ ./openshift-install --dir <installation_directory> wait-for bootstrap-complete \ 1
    --log-level=info 2
```

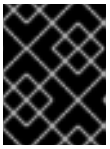
1. For **<installation_directory>**, specify the path to the directory that you stored the installation files in.
2. To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

Example output

```
INFO Waiting up to 30m0s for the Kubernetes API at https://api.test.example.com:6443...
INFO API v1.24.0 up
INFO Waiting up to 30m0s for bootstrapping to complete...
INFO It is now safe to remove the bootstrap resources
```

The command succeeds when the Kubernetes API server signals that it has been bootstrapped on the control plane machines.

2. After the bootstrap process is complete, remove the bootstrap machine from the load balancer.



IMPORTANT

You must remove the bootstrap machine from the load balancer at this point. You can also remove or reformat the bootstrap machine itself.

Additional resources

- See Monitoring installation progress for more information about monitoring the installation logs and retrieving diagnostic data if installation issues arise.

11.3.16. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

Example output

```
system:admin
```

11.3.17. Approving the certificate signing requests for your machines

When you add machines to a cluster, two pending certificate signing requests (CSRs) are generated for each machine that you added. You must confirm that these CSRs are approved or, if necessary, approve them yourself. The client requests must be approved first, followed by the server requests.

Prerequisites

- You added machines to your cluster.

Procedure

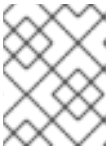
1. Confirm that the cluster recognizes the machines:

```
$ oc get nodes
```

Example output

```
NAME      STATUS    ROLES   AGE  VERSION
master-0  Ready     master  63m  v1.24.0
master-1  Ready     master  63m  v1.24.0
master-2  Ready     master  64m  v1.24.0
```

The output lists all of the machines that you created.



NOTE

The preceding output might not include the compute nodes, also known as worker nodes, until some CSRs are approved.

2. Review the pending CSRs and ensure that you see the client requests with the **Pending** or **Approved** status for each machine that you added to the cluster:

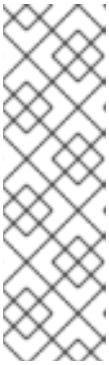
```
$ oc get csr
```

Example output

```
NAME        AGE     REQUESTOR                                                   CONDITION
csr-8b2br   15m     system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper   Pending
csr-8vnps   15m     system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper   Pending
...
```

In this example, two machines are joining the cluster. You might see more approved CSRs in the list.

3. If the CSRs were not approved, after all of the pending CSRs for the machines you added are in **Pending** status, approve the CSRs for your cluster machines:



NOTE

Because the CSRs rotate automatically, approve your CSRs within an hour of adding the machines to the cluster. If you do not approve them within an hour, the certificates will rotate, and more than two certificates will be present for each node. You must approve all of these certificates. After the client CSR is approved, the Kubelet creates a secondary CSR for the serving certificate, which requires manual approval. Then, subsequent serving certificate renewal requests are automatically approved by the **machine-approver** if the Kubelet requests a new certificate with identical parameters.

NOTE

For clusters running on platforms that are not machine API enabled, such as bare metal and other user-provisioned infrastructure, you must implement a method of automatically approving the kubelet serving certificate requests (CSRs). If a request is not approved, then the **oc exec**, **oc rsh**, and **oc logs** commands cannot succeed, because a serving certificate is required when the API server connects to the kubelet. Any operation that contacts the Kubelet endpoint requires this certificate approval to be in place. The method must watch for new CSRs, confirm that the CSR was submitted by the **node-bootstrapper** service account in the **system:node** or **system:admin** groups, and confirm the identity of the node.

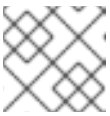
- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

1 **<csr_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{{"\n"}}
{{end}}{{end}}' | xargs --no-run-if-empty oc adm certificate approve
```



NOTE

Some Operators might not become available until some CSRs are approved.

4. Now that your client requests are approved, you must review the server requests for each machine that you added to the cluster:

```
$ oc get csr
```

Example output

```
NAME        AGE     REQUESTOR                                                   CONDITION
csr-bfd72   5m26s   system:node:ip-10-0-50-126.us-east-2.compute.internal
Pending
csr-c57lv   5m26s   system:node:ip-10-0-95-157.us-east-2.compute.internal
Pending
...
```

5. If the remaining CSRs are not approved, and are in the **Pending** status, approve the CSRs for your cluster machines:

   - To approve them individually, run the following command for each valid CSR:

     ```
     $ oc adm certificate approve <csr_name> 1
     ```

     1 **<csr_name>** is the name of a CSR from the list of current CSRs.

   - To approve all pending CSRs, run the following command:

     ```
     $ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{{"\n"}}
     {{end}}{{end}}' | xargs oc adm certificate approve
     ```

6. After all client and server CSRs have been approved, the machines have the **Ready** status. Verify this by running the following command:

   ```
   $ oc get nodes
   ```

   Example output

   ```
   NAME      STATUS    ROLES   AGE  VERSION
   master-0  Ready     master  73m  v1.24.0
   master-1  Ready     master  73m  v1.24.0
   master-2  Ready     master  74m  v1.24.0
   worker-0  Ready     worker  11m  v1.24.0
   worker-1  Ready     worker  11m  v1.24.0
   ```

   NOTE

   It can take a few minutes after approval of the server CSRs for the machines to transition to the **Ready** status.

Additional information

- For more information on CSRs, see Certificate Signing Requests.

11.3.18. Initial Operator configuration

After the control plane initializes, you must immediately configure some Operators so that they all become available.

Prerequisites

- Your control plane has initialized.

Procedure

1. Watch the cluster components come online:

   ```
   $ watch -n5 oc get clusteroperators
   ```

Example output

```
NAME                                       VERSION   AVAILABLE   PROGRESSING   DEGRADED
SINCE
authentication                             4.11.0    True        False         False      19m
baremetal                                  4.11.0    True        False         False      37m
cloud-credential                           4.11.0    True        False         False      40m
cluster-autoscaler                         4.11.0    True        False         False      37m
config-operator                            4.11.0    True        False         False      38m
console                                    4.11.0    True        False         False      26m
csi-snapshot-controller                    4.11.0    True        False         False      37m
dns                                        4.11.0    True        False         False      37m
etcd                                       4.11.0    True        False         False      36m
image-registry                             4.11.0    True        False         False      31m
ingress                                    4.11.0    True        False         False      30m
insights                                   4.11.0    True        False         False      31m
kube-apiserver                             4.11.0    True        False         False      26m
kube-controller-manager                    4.11.0    True        False         False      36m
kube-scheduler                             4.11.0    True        False         False      36m
kube-storage-version-migrator              4.11.0    True        False         False      37m
machine-api                                4.11.0    True        False         False      29m
machine-approver                           4.11.0    True        False         False      37m
machine-config                             4.11.0    True        False         False      36m
marketplace                                4.11.0    True        False         False      37m
monitoring                                 4.11.0    True        False         False      29m
network                                    4.11.0    True        False         False      38m
node-tuning                                4.11.0    True        False         False      37m
openshift-apiserver                        4.11.0    True        False         False      32m
openshift-controller-manager               4.11.0    True        False         False      30m
openshift-samples                          4.11.0    True        False         False      32m
operator-lifecycle-manager                 4.11.0    True        False         False      37m
operator-lifecycle-manager-catalog         4.11.0    True        False         False      37m
operator-lifecycle-manager-packageserver   4.11.0    True        False         False      32m
service-ca                                 4.11.0    True        False         False      38m
storage                                    4.11.0    True        False         False      37m
```

2. Configure the Operators that are not available.

Additional resources

- See Gathering logs from a failed installation for details about gathering data in the event of a failed OpenShift Container Platform installation.
- See Troubleshooting Operator issues for steps to check Operator pod health across the cluster and gather Operator logs for diagnosis.

11.3.18.1. Image registry removed during installation

On platforms that do not provide shareable object storage, the OpenShift Image Registry Operator bootstraps itself as **Removed**. This allows **openshift-installer** to complete installations on these platform types.

After installation, you must edit the Image Registry Operator configuration to switch the **managementState** from **Removed** to **Managed**.

11.3.18.2. Image registry storage configuration

The Image Registry Operator is not initially available for platforms that do not provide default storage. After installation, you must configure your registry to use storage so that the Registry Operator is made available.

Instructions are shown for configuring a persistent volume, which is required for production clusters. Where applicable, instructions are shown for configuring an empty directory as the storage location, which is available for only non-production clusters.

Additional instructions are provided for allowing the image registry to use block storage types by using the **Recreate** rollout strategy during upgrades.

11.3.18.3. Configuring block registry storage for bare metal

To allow the image registry to use block storage types during upgrades as a cluster administrator, you can use the **Recreate** rollout strategy.

IMPORTANT

Block storage volumes, or block persistent volumes, are supported but not recommended for use with the image registry on production clusters. An installation where the registry is configured on block storage is not highly available because the registry cannot have more than one replica.

If you choose to use a block storage volume with the image registry, you must use a filesystem persistent volume claim (PVC).

Procedure

1. Enter the following command to set the image registry storage as a block storage type, patch the registry so that it uses the **Recreate** rollout strategy, and runs with only one (**1**) replica:

```
$ oc patch config.imageregistry.operator.openshift.io/cluster --type=merge -p '{"spec":
{"rolloutStrategy":"Recreate","replicas":1}}'
```

2. Provision the PV for the block storage device, and create a PVC for that volume. The requested block volume uses the ReadWriteOnce (RWO) access mode.

   a. Create a **pvc.yaml** file with the following contents to define a VMware vSphere **PersistentVolumeClaim** object:

```
kind: PersistentVolumeClaim
apiVersion: v1
metadata:
  name: image-registry-storage 1
  namespace: openshift-image-registry 2
spec:
  accessModes:
  - ReadWriteOnce 3
  resources:
    requests:
      storage: 100Gi 4
```

1. A unique name that represents the **PersistentVolumeClaim** object.
2. The namespace for the **PersistentVolumeClaim** object, which is **openshift-image-registry**.
3. The access mode of the persistent volume claim. With **ReadWriteOnce**, the volume can be mounted with read and write permissions by a single node.
4. The size of the persistent volume claim.

b. Enter the following command to create the **PersistentVolumeClaim** object from the file:

```
$ oc create -f pvc.yaml -n openshift-image-registry
```

3. Enter the following command to edit the registry configuration so that it references the correct PVC:

```
$ oc edit config.imageregistry.operator.openshift.io -o yaml
```

Example output

```
storage:
  pvc:
    claim: 1
```

1. By creating a custom PVC, you can leave the **claim** field blank for the default automatic creation of an **image-registry-storage** PVC.

11.3.19. Completing installation on user-provisioned infrastructure

After you complete the Operator configuration, you can finish installing the cluster on infrastructure that you provide.

Prerequisites

- Your control plane has initialized.
- You have completed the initial Operator configuration.

Procedure

1. Confirm that all the cluster components are online with the following command:

```
$ watch -n5 oc get clusteroperators
```

Example output

```
NAME                                       VERSION   AVAILABLE   PROGRESSING   DEGRADED
SINCE
authentication                              4.11.0    True        False         False     19m
baremetal                                  4.11.0    True        False         False     37m
```

```
cloud-credential                           4.11.0    True        False       False      40m
cluster-autoscaler                         4.11.0    True        False       False      37m
config-operator                            4.11.0    True        False       False      38m
console                                    4.11.0    True        False       False      26m
csi-snapshot-controller                    4.11.0    True        False       False      37m
dns                                        4.11.0    True        False       False      37m
etcd                                       4.11.0    True        False       False      36m
image-registry                             4.11.0    True        False       False      31m
ingress                                    4.11.0    True        False       False      30m
insights                                   4.11.0    True        False       False      31m
kube-apiserver                             4.11.0    True        False       False      26m
kube-controller-manager                    4.11.0    True        False       False      36m
kube-scheduler                             4.11.0    True        False       False      36m
kube-storage-version-migrator              4.11.0    True        False       False      37m
machine-api                                4.11.0    True        False       False      29m
machine-approver                           4.11.0    True        False       False      37m
machine-config                             4.11.0    True        False       False      36m
marketplace                                4.11.0    True        False       False      37m
monitoring                                 4.11.0    True        False       False      29m
network                                    4.11.0    True        False       False      38m
node-tuning                                4.11.0    True        False       False      37m
openshift-apiserver                        4.11.0    True        False       False      32m
openshift-controller-manager               4.11.0    True        False       False      30m
openshift-samples                          4.11.0    True        False       False      32m
operator-lifecycle-manager                 4.11.0    True        False       False      37m
operator-lifecycle-manager-catalog         4.11.0    True        False       False      37m
operator-lifecycle-manager-packageserver   4.11.0    True        False       False      32m
service-ca                                 4.11.0    True        False       False      38m
storage                                    4.11.0    True        False       False      37m
```

Alternatively, the following command notifies you when all of the clusters are available. It also retrieves and displays credentials:

```
$ ./openshift-install --dir <installation_directory> wait-for install-complete 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

Example output

```
INFO Waiting up to 30m0s for the cluster to initialize...
```

The command succeeds when the Cluster Version Operator finishes deploying the OpenShift Container Platform cluster from Kubernetes API server.

IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

2. Confirm that the Kubernetes API server is communicating with the pods.

   a. To view a list of all pods, use the following command:

   ```
   $ oc get pods --all-namespaces
   ```

   Example output

   ```
   NAMESPACE                       NAME                                        READY   STATUS
   RESTARTS   AGE
   openshift-apiserver-operator    openshift-apiserver-operator-85cb746d55-zqhs8   1/1
   Running    1          9m
   openshift-apiserver             apiserver-67b9g                               1/1     Running     0
   3m
   openshift-apiserver             apiserver-ljcmx                               1/1     Running     0
   1m
   openshift-apiserver             apiserver-z25h4                               1/1     Running     0
   2m
   openshift-authentication-operator authentication-operator-69d5d8bf84-vh2n8        1/1
   Running    0          5m
   ...
   ```

   b. View the logs for a pod that is listed in the output of the previous command by using the following command:

   ```
   $ oc logs <pod_name> -n <namespace> 1
   ```

   1 Specify the pod name and namespace, as shown in the output of the previous command.

   If the pod logs display, the Kubernetes API server can communicate with the cluster machines.

3. For an installation with Fibre Channel Protocol (FCP), additional steps are required to enable multipathing. Do not enable multipathing during installation.
   See "Enabling multipathing with kernel arguments on RHCOS" in the *Post-installation machine configuration tasks* documentation for more information.

11.3.20. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.11, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to OpenShift Cluster Manager Hybrid Cloud Console.

After you confirm that your OpenShift Cluster Manager Hybrid Cloud Console inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, use subscription watch to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

Additional resources

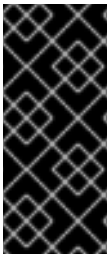
- See About remote health monitoring for more information about the Telemetry service

11.3.21. Next steps

- Validating an installation.
- Customize your cluster.
- If necessary, you can opt out of remote health reporting .
- Set up your registry and configure registry storage .

11.4. INSTALLING A USER-PROVISIONED BARE METAL CLUSTER ON A RESTRICTED NETWORK

In OpenShift Container Platform 4.11, you can install a cluster on bare metal infrastructure that you provision in a restricted network.

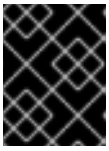


IMPORTANT

While you might be able to follow this procedure to deploy a cluster on virtualized or cloud environments, you must be aware of additional considerations for non-bare metal platforms. Review the information in the guidelines for deploying OpenShift Container Platform on non-tested platforms before you attempt to install an OpenShift Container Platform cluster in such an environment.

11.4.1. Prerequisites

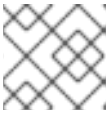
- You reviewed details about the OpenShift Container Platform installation and update processes.
- You read the documentation on selecting a cluster installation method and preparing it for users.
- You created a registry on your mirror host and obtained the **imageContentSources** data for your version of OpenShift Container Platform.



IMPORTANT

Because the installation media is on the mirror host, you can use that computer to complete all installation steps.

- You provisioned persistent storage for your cluster. To deploy a private image registry, your storage must provide ReadWriteMany access modes.
- If you use a firewall and plan to use the Telemetry service, you configured the firewall to allow the sites that your cluster requires access to.



NOTE

Be sure to also review this site list if you are configuring a proxy.

11.4.2. About installations in restricted networks

In OpenShift Container Platform 4.11, you can perform an installation that does not require an active connection to the internet to obtain software components. Restricted network installations can be completed using installer-provisioned infrastructure or user-provisioned infrastructure, depending on the cloud platform to which you are installing the cluster.

If you choose to perform a restricted network installation on a cloud platform, you still require access to its cloud APIs. Some cloud functions, like Amazon Web Service's Route 53 DNS and IAM services, require internet access. Depending on your network, you might require less internet access for an installation on bare metal hardware or on VMware vSphere.

To complete a restricted network installation, you must create a registry that mirrors the contents of the OpenShift image registry and contains the installation media. You can create this registry on a mirror host, which can access both the internet and your closed network, or by using other methods that meet your restrictions.

IMPORTANT

Because of the complexity of the configuration for user-provisioned installations, consider completing a standard user-provisioned infrastructure installation before you attempt a restricted network installation using user-provisioned infrastructure. Completing this test installation might make it easier to isolate and troubleshoot any issues that might arise during your installation in a restricted network.

11.4.2.1. Additional limits

Clusters in restricted networks have the following additional limitations and restrictions:

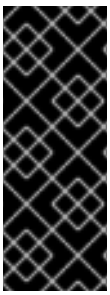
- The **ClusterVersion** status includes an **Unable to retrieve available updates** error.
- By default, you cannot use the contents of the Developer Catalog because you cannot access the required image stream tags.

11.4.3. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.11, you require access to the internet to obtain the images that are necessary to install your cluster.

You must have internet access to:

- Access OpenShift Cluster Manager Hybrid Cloud Console to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access Quay.io to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.



IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

11.4.4. Requirements for a cluster with user-provisioned infrastructure

For a cluster that contains user-provisioned infrastructure, you must deploy all of the required machines.

This section describes the requirements for deploying OpenShift Container Platform on user-provisioned infrastructure.

11.4.4.1. Required machines for cluster installation

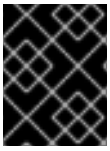
The smallest OpenShift Container Platform clusters require the following hosts:

Table 11.34. Minimum required hosts

Hosts	Description
One temporary bootstrap machine	The cluster requires the bootstrap machine to deploy the OpenShift Container Platform cluster on the three control plane machines. You can remove the bootstrap machine after you install the cluster.
Three control plane machines	The control plane machines run the Kubernetes and OpenShift Container Platform services that form the control plane.
At least two compute machines, which are also known as worker machines.	The workloads requested by OpenShift Container Platform users run on the compute machines.

NOTE

As an exception, you can run zero compute machines in a bare metal cluster that consists of three control plane machines only. This provides smaller, more resource efficient clusters for cluster administrators and developers to use for testing, development, and production. Running one compute machine is not supported.



IMPORTANT

To maintain high availability of your cluster, use separate physical hosts for these cluster machines.

The bootstrap and control plane machines must use Red Hat Enterprise Linux CoreOS (RHCOS) as the operating system. However, the compute machines can choose between Red Hat Enterprise Linux CoreOS (RHCOS), Red Hat Enterprise Linux (RHEL) 8.6 and later.

Note that RHCOS is based on Red Hat Enterprise Linux (RHEL) 8 and inherits all of its hardware certifications and requirements. See Red Hat Enterprise Linux technology capabilities and limits .

11.4.4.2. Minimum resource requirements for cluster installation

Each cluster machine must meet the following minimum requirements:

Table 11.35. Minimum resource requirements

Machine	Operating System	CPU [1]	RAM	Storage	IOPS [2]
Bootstrap	RHCOS	4	16 GB	100 GB	300
Control plane	RHCOS	4	16 GB	100 GB	300
Compute	RHCOS, RHEL 8.6 and later [3]	2	8 GB	100 GB	300

1. One CPU is equivalent to one physical core when simultaneous multithreading (SMT), or hyperthreading, is not enabled. When enabled, use the following formula to calculate the corresponding ratio: (threads per core × cores) × sockets = CPUs.

2. OpenShift Container Platform and Kubernetes are sensitive to disk performance, and faster storage is recommended, particularly for etcd on the control plane nodes which require a 10 ms p99 fsync duration. Note that on many cloud platforms, storage size and IOPS scale together, so you might need to over-allocate storage volume to obtain sufficient performance.

3. As with all user-provisioned installations, if you choose to use RHEL compute machines in your cluster, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks. Use of RHEL 7 compute machines is deprecated and has been removed in OpenShift Container Platform 4.10 and later.

If an instance type for your platform meets the minimum requirements for cluster machines, it is supported to use in OpenShift Container Platform.

Additional resources

- Optimizing storage

11.4.4.3. Certificate signing requests management

Because your cluster has limited access to automatic machine management when you use infrastructure that you provision, you must provide a mechanism for approving cluster certificate signing requests (CSRs) after installation. The **kube-controller-manager** only approves the kubelet client CSRs. The **machine-approver** cannot guarantee the validity of a serving certificate that is requested by using kubelet credentials because it cannot confirm that the correct machine issued the request. You must determine and implement a method of verifying the validity of the kubelet serving certificate requests and approving them.

Additional resources

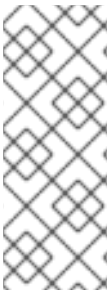
- See Configuring a three-node cluster for details about deploying three-node clusters in bare metal environments.
- See Approving the certificate signing requests for your machines for more information about approving cluster certificate signing requests after installation.

11.4.4.4. Networking requirements for user-provisioned infrastructure

All the Red Hat Enterprise Linux CoreOS (RHCOS) machines require networking to be configured in **initramfs** during boot to fetch their Ignition config files.

During the initial boot, the machines require an IP address configuration that is set either through a DHCP server or statically by providing the required boot options. After a network connection is established, the machines download their Ignition config files from an HTTP or HTTPS server. The Ignition config files are then used to set the exact state of each machine. The Machine Config Operator completes more changes to the machines, such as the application of new certificates or keys, after installation.

It is recommended to use a DHCP server for long-term management of the cluster machines. Ensure that the DHCP server is configured to provide persistent IP addresses, DNS server information, and hostnames to the cluster machines.



NOTE

If a DHCP service is not available for your user-provisioned infrastructure, you can instead provide the IP networking configuration and the address of the DNS server to the nodes at RHCOS install time. These can be passed as boot arguments if you are installing from an ISO image. See the *Installing RHCOS and starting the OpenShift Container Platform bootstrap process* section for more information about static IP provisioning and advanced networking options.

The Kubernetes API server must be able to resolve the node names of the cluster machines. If the API servers and worker nodes are in different zones, you can configure a default DNS search zone to allow the API server to resolve the node names. Another supported approach is to always refer to hosts by their fully-qualified domain names in both the node objects and all DNS requests.

11.4.4.4.1. Setting the cluster node hostnames through DHCP

On Red Hat Enterprise Linux CoreOS (RHCOS) machines, the hostname is set through NetworkManager. By default, the machines obtain their hostname through DHCP. If the hostname is not provided by DHCP, set statically through kernel arguments, or another method, it is obtained through a reverse DNS lookup. Reverse DNS lookup occurs after the network has been initialized on a node and can take time to resolve. Other system services can start prior to this and detect the hostname as **localhost** or similar. You can avoid this by using DHCP to provide the hostname for each cluster node.

Additionally, setting the hostnames through DHCP can bypass any manual DNS record name configuration errors in environments that have a DNS split-horizon implementation.

11.4.4.4.2. Network connectivity requirements

You must configure the network connectivity between machines to allow OpenShift Container Platform cluster components to communicate. Each machine must be able to resolve the hostnames of all other machines in the cluster.

This section provides details about the ports that are required.

Table 11.36. Ports used for all-machine to all-machine communications

Protocol	Port	Description
ICMP	N/A	Network reachability tests
TCP	**1936**	Metrics
	9000-**9999**	Host level services, including the node exporter on ports **9100**-**9101** and the Cluster Version Operator on port**9099**.
	10250-**10259**	The default ports that Kubernetes reserves
	10256	openshift-sdn
UDP	**4789**	VXLAN
	6081	Geneve
	9000-**9999**	Host level services, including the node exporter on ports **9100**-**9101**.
	500	IPsec IKE packets
	4500	IPsec NAT-T packets
TCP/UDP	**30000**-**32767**	Kubernetes node port
ESP	N/A	IPsec Encapsulating Security Payload (ESP)

Table 11.37. Ports used for all-machine to control plane communications

Protocol	Port	Description
TCP	**6443**	Kubernetes API

Table 11.38. Ports used for control plane machine to control plane machine communications

Protocol	Port	Description
TCP	**2379-2380**	etcd server and peer ports

NTP configuration for user-provisioned infrastructure
OpenShift Container Platform clusters are configured to use a public Network Time Protocol (NTP) server by default. If you want to use a local enterprise NTP server, or if your cluster is being deployed in a disconnected network, you can configure the cluster to use a specific time server. For more information, see the documentation for *Configuring chrony time service* .

If a DHCP server provides NTP server information, the chrony time service on the Red Hat Enterprise Linux CoreOS (RHCOS) machines read the information and can sync the clock with the NTP servers.

Additional resources

- Configuring chrony time service

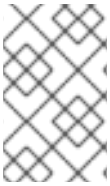
11.4.4.5. User-provisioned DNS requirements

In OpenShift Container Platform deployments, DNS name resolution is required for the following components:

- The Kubernetes API
- The OpenShift Container Platform application wildcard
- The bootstrap, control plane, and compute machines

Reverse DNS resolution is also required for the Kubernetes API, the bootstrap machine, the control plane machines, and the compute machines.

DNS A/AAAA or CNAME records are used for name resolution and PTR records are used for reverse name resolution. The reverse records are important because Red Hat Enterprise Linux CoreOS (RHCOS) uses the reverse records to set the hostnames for all the nodes, unless the hostnames are provided by DHCP. Additionally, the reverse records are used to generate the certificate signing requests (CSR) that OpenShift Container Platform needs to operate.

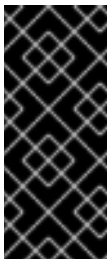


NOTE

It is recommended to use a DHCP server to provide the hostnames to each cluster node. See the *DHCP recommendations for user-provisioned infrastructure* section for more information.

The following DNS records are required for a user-provisioned OpenShift Container Platform cluster and they must be in place before installation. In each record, **<cluster_name>** is the cluster name and **<base_domain>** is the base domain that you specify in the **install-config.yaml** file. A complete DNS record takes the form: **<component>.<cluster_name>.<base_domain>.**.

Table 11.39. Required DNS records

Component	Record	Description
Kubernetes API	**api.<cluster_name>.<base_domain>.**	A DNS A/AAAA or CNAME record, and a DNS PTR record, to identify the API load balancer. These records must be resolvable by both clients external to the cluster and from all the nodes within the cluster.
	api-int.<cluster_name>.<base_domain>.	A DNS A/AAAA or CNAME record, and a DNS PTR record, to internally identify the API load balancer. These records must be resolvable from all the nodes within the cluster.  **IMPORTANT** The API server must be able to resolve the worker nodes by the hostnames that are recorded in Kubernetes. If the API server cannot resolve the node names, then proxied API calls can fail, and you cannot retrieve logs from pods.
Routes	***.apps.<cluster_name>.<base_domain>.**	A wildcard DNS A/AAAA or CNAME record that refers to the application ingress load balancer. The application ingress load balancer targets the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default. These records must be resolvable by both clients external to the cluster and from all the nodes within the cluster. For example, **console-openshift-console.apps.<cluster_name>.<base_domain>** is used as a wildcard route to the OpenShift Container Platform console.
Bootstrap machine	**bootstrap.<cluster_name>.<base_domain>.**	A DNS A/AAAA or CNAME record, and a DNS PTR record, to identify the bootstrap machine. These records must be resolvable by the nodes within the cluster.
Control plane machines	**<master><n>.<cluster_name>.<base_domain>.**	DNS A/AAAA or CNAME records and DNS PTR records to identify each machine for the control plane nodes. These records must be resolvable by the nodes within the cluster.
Compute machines	**<worker><n>.<cluster_name>.<base_domain>.**	DNS A/AAAA or CNAME records and DNS PTR records to identify each machine for the worker nodes. These records must be resolvable by the nodes within the cluster.

NOTE

In OpenShift Container Platform 4.4 and later, you do not need to specify etcd host and SRV records in your DNS configuration.

TIP

You can use the **dig** command to verify name and reverse name resolution. See the section on *Validating DNS resolution for user-provisioned infrastructure* for detailed validation steps.

11.4.4.5.1. Example DNS configuration for user-provisioned clusters

This section provides A and PTR record configuration samples that meet the DNS requirements for deploying OpenShift Container Platform on user-provisioned infrastructure. The samples are not meant to provide advice for choosing one DNS solution over another.

In the examples, the cluster name is **ocp4** and the base domain is **example.com**.

Example DNS A record configuration for a user-provisioned cluster

The following example is a BIND zone file that shows sample A records for name resolution in a user-provisioned cluster.

Example 11.7. Sample DNS zone database

```
$TTL 1W
@ IN SOA ns1.example.com. root (
  2019070700 ; serial
  3H  ; refresh (3 hours)
  30M  ; retry (30 minutes)
  2W  ; expiry (2 weeks)
  1W )  ; minimum (1 week)
 IN NS ns1.example.com.
 IN MX 10 smtp.example.com.
;
;
ns1.example.com.  IN A 192.168.1.5
smtp.example.com.  IN A 192.168.1.5
;
helper.example.com.  IN A 192.168.1.5
helper.ocp4.example.com. IN A 192.168.1.5
;
api.ocp4.example.com.  IN A 192.168.1.5 1
api-int.ocp4.example.com. IN A 192.168.1.5 2
;
*.apps.ocp4.example.com. IN A 192.168.1.5 3
;
bootstrap.ocp4.example.com. IN A 192.168.1.96 4
;
master0.ocp4.example.com. IN A 192.168.1.97 5
master1.ocp4.example.com. IN A 192.168.1.98 6
master2.ocp4.example.com. IN A 192.168.1.99 7
;
worker0.ocp4.example.com. IN A 192.168.1.11 8
worker1.ocp4.example.com. IN A 192.168.1.7 9
;
;EOF
```

1 Provides name resolution for the Kubernetes API. The record refers to the IP address of the API load balancer.

2 Provides name resolution for the Kubernetes API. The record refers to the IP address of the API load balancer and is used for internal cluster communications.

3 Provides name resolution for the wildcard routes. The record refers to the IP address of the application ingress load balancer. The application ingress load balancer targets the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.

NOTE

In the example, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

4 Provides name resolution for the bootstrap machine.

5 6 7 Provides name resolution for the control plane machines.

8 9 Provides name resolution for the compute machines.

Example DNS PTR record configuration for a user-provisioned cluster

The following example BIND zone file shows sample PTR records for reverse name resolution in a user-provisioned cluster.

Example 11.8. Sample DNS zone database for reverse records

```
$TTL 1W
@ IN SOA ns1.example.com. root (
  2019070700 ; serial
  3H  ; refresh (3 hours)
  30M  ; retry (30 minutes)
  2W  ; expiry (2 weeks)
  1W )  ; minimum (1 week)
 IN NS ns1.example.com.
;
5.1.168.192.in-addr.arpa. IN PTR api.ocp4.example.com. 1
5.1.168.192.in-addr.arpa. IN PTR api-int.ocp4.example.com. 2
;
96.1.168.192.in-addr.arpa. IN PTR bootstrap.ocp4.example.com. 3
;
97.1.168.192.in-addr.arpa. IN PTR master0.ocp4.example.com. 4
98.1.168.192.in-addr.arpa. IN PTR master1.ocp4.example.com. 5
99.1.168.192.in-addr.arpa. IN PTR master2.ocp4.example.com. 6
;
11.1.168.192.in-addr.arpa. IN PTR worker0.ocp4.example.com. 7
7.1.168.192.in-addr.arpa. IN PTR worker1.ocp4.example.com. 8
;
;EOF
```

1. Provides reverse DNS resolution for the Kubernetes API. The PTR record refers to the record name of the API load balancer.
2. Provides reverse DNS resolution for the Kubernetes API. The PTR record refers to the record name of the API load balancer and is used for internal cluster communications.
3. Provides reverse DNS resolution for the bootstrap machine.
4 5 6. Provides reverse DNS resolution for the control plane machines.
7 8. Provides reverse DNS resolution for the compute machines.

NOTE

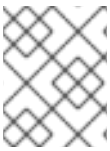
A PTR record is not required for the OpenShift Container Platform application wildcard.

Additional resources

- Validating DNS resolution for user-provisioned infrastructure

11.4.4.6. Load balancing requirements for user-provisioned infrastructure

Before you install OpenShift Container Platform, you must provision the API and application ingress load balancing infrastructure. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

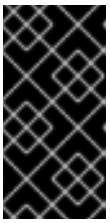


NOTE

If you want to deploy the API and application Ingress load balancers with a Red Hat Enterprise Linux (RHEL) instance, you must purchase the RHEL subscription separately.

The load balancing infrastructure must meet the following requirements:

1. **API load balancer**: Provides a common endpoint for users, both human and machine, to interact with and configure the platform. Configure the following conditions:
   - Layer 4 load balancing only. This can be referred to as Raw TCP, SSL Passthrough, or SSL Bridge mode. If you use SSL Bridge mode, you must enable Server Name Indication (SNI) for the API routes.
   - A stateless load balancing algorithm. The options vary based on the load balancer implementation.



IMPORTANT

Do not configure session persistence for an API load balancer. Configuring session persistence for a Kubernetes API server might cause performance issues from excess application traffic for your OpenShift Container Platform cluster and the Kubernetes API that runs inside the cluster.

Configure the following ports on both the front and back of the load balancers:

Table 11.40. API load balancer

Port	Back-end machines (pool members)	Internal	External	Description
6443	Bootstrap and control plane. You remove the bootstrap machine from the load balancer after the bootstrap machine initializes the cluster control plane. You must configure the **/readyz** endpoint for the API server health check probe.	X	X	Kubernetes API server
22623	Bootstrap and control plane. You remove the bootstrap machine from the load balancer after the bootstrap machine initializes the cluster control plane.	X		Machine config server

NOTE

The load balancer must be configured to take a maximum of 30 seconds from the time the API server turns off the **/readyz** endpoint to the removal of the API server instance from the pool. Within the time frame after **/readyz** returns an error or becomes healthy, the endpoint must have been removed or added. Probing every 5 or 10 seconds, with two successful requests to become healthy and three to become unhealthy, are well-tested values.

2. **Application Ingress load balancer**: Provides an ingress point for application traffic flowing in from outside the cluster. A working configuration for the Ingress router is required for an OpenShift Container Platform cluster.
Configure the following conditions:

   - Layer 4 load balancing only. This can be referred to as Raw TCP, SSL Passthrough, or SSL Bridge mode. If you use SSL Bridge mode, you must enable Server Name Indication (SNI) for the ingress routes.
   - A connection-based or session-based persistence is recommended, based on the options available and types of applications that will be hosted on the platform.

TIP

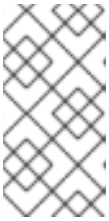
If the true IP address of the client can be seen by the application Ingress load balancer, enabling source IP-based session persistence can improve performance for applications that use end-to-end TLS encryption.

Configure the following ports on both the front and back of the load balancers:

Table 11.41. Application Ingress load balancer

Port	Back-end machines (pool members)	Internal	External	Description

Port	Back-end machines (pool members)	Internal	External	Description
443	The machines that run the Ingress Controller pods, compute, or worker, by default.	X	X	HTTPS traffic
80	The machines that run the Ingress Controller pods, compute, or worker, by default.	X	X	HTTP traffic



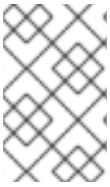
NOTE

If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application Ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes.

11.4.4.6.1. Example load balancer configuration for user-provisioned clusters

This section provides an example API and application ingress load balancer configuration that meets the load balancing requirements for user-provisioned clusters. The sample is an **/etc/haproxy/haproxy.cfg** configuration for an HAProxy load balancer. The example is not meant to provide advice for choosing one load balancing solution over another.

In the example, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.



NOTE

If you are using HAProxy as a load balancer and SELinux is set to **enforcing**, you must ensure that the HAProxy service can bind to the configured TCP port by running **setsebool -P haproxy_connect_any=1**.

Example 11.9. Sample API and application Ingress load balancer configuration

```
global
  log         127.0.0.1 local2
  pidfile     /var/run/haproxy.pid
  maxconn     4000
  daemon
defaults
  mode                    http
  log                     global
  option                  dontlognull
  option http-server-close
  option                  redispatch
  retries                 3
  timeout http-request    10s
  timeout queue           1m
  timeout connect         10s
  timeout client          1m
```

```
  timeout server          1m
  timeout http-keep-alive 10s
  timeout check           10s
  maxconn                 3000
listen api-server-6443 1
  bind *:6443
  mode tcp
  server bootstrap bootstrap.ocp4.example.com:6443 check inter 1s backup 2
  server master0 master0.ocp4.example.com:6443 check inter 1s
  server master1 master1.ocp4.example.com:6443 check inter 1s
  server master2 master2.ocp4.example.com:6443 check inter 1s
listen machine-config-server-22623 3
  bind *:22623
  mode tcp
  option  httpchk GET /readyz HTTP/1.0
  option  log-health-checks
  balance roundrobin
  server bootstrap bootstrap.ocp4.example.com:6443 verify none check check-ssl inter 10s fall 2
rise 3 backup 4
  server master0 master0.ocp4.example.com:6443 weight 1 verify none check check-ssl inter 10s
fall 2 rise 3
  server master1 master1.ocp4.example.com:6443 weight 1 verify none check check-ssl inter 10s
fall 2 rise 3
  server master2 master2.ocp4.example.com:6443 weight 1 verify none check check-ssl inter 10s
fall 2 rise 3
listen ingress-router-443 5
  bind *:443
  mode tcp
  balance source
  server worker0 worker0.ocp4.example.com:443 check inter 1s
  server worker1 worker1.ocp4.example.com:443 check inter 1s
listen ingress-router-80 6
  bind *:80
  mode tcp
  balance source
  server worker0 worker0.ocp4.example.com:80 check inter 1s
  server worker1 worker1.ocp4.example.com:80 check inter 1s
```

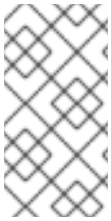
1 Port **6443** handles the Kubernetes API traffic and points to the control plane machines.

2 4 The bootstrap entries must be in place before the OpenShift Container Platform cluster installation and they must be removed after the bootstrap process is complete.

3 Port **22623** handles the machine config server traffic and points to the control plane machines.

5 Port **443** handles the HTTPS traffic and points to the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.

6 Port **80** handles the HTTP traffic and points to the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.



NOTE

If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application Ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes.

TIP

If you are using HAProxy as a load balancer, you can check that the **haproxy** process is listening on ports **6443**, **22623**, **443**, and **80** by running **netstat -nltupe** on the HAProxy node.

11.4.5. Preparing the user-provisioned infrastructure

Before you install OpenShift Container Platform on user-provisioned infrastructure, you must prepare the underlying infrastructure.

This section provides details about the high-level steps required to set up your cluster infrastructure in preparation for an OpenShift Container Platform installation. This includes configuring IP networking and network connectivity for your cluster nodes, enabling the required ports through your firewall, and setting up the required DNS and load balancing infrastructure.

After preparation, your cluster infrastructure must meet the requirements outlined in the *Requirements for a cluster with user-provisioned infrastructure* section.

Prerequisites

- You have reviewed the OpenShift Container Platform 4.x Tested Integrations page.
- You have reviewed the infrastructure requirements detailed in the *Requirements for a cluster with user-provisioned infrastructure* section.

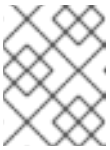
Procedure

1. If you are using DHCP to provide the IP networking configuration to your cluster nodes, configure your DHCP service.
   a. Add persistent IP addresses for the nodes to your DHCP server configuration. In your configuration, match the MAC address of the relevant network interface to the intended IP address for each node.
   b. When you use DHCP to configure IP addressing for the cluster machines, the machines also obtain the DNS server information through DHCP. Define the persistent DNS server address that is used by the cluster nodes through your DHCP server configuration.

NOTE

If you are not using a DHCP service, you must provide the IP networking configuration and the address of the DNS server to the nodes at RHCOS install time. These can be passed as boot arguments if you are installing from an ISO image. See the *Installing RHCOS and starting the OpenShift Container Platform bootstrap process* section for more information about static IP provisioning and advanced networking options.

c. Define the hostnames of your cluster nodes in your DHCP server configuration. See the *Setting the cluster node hostnames through DHCP* section for details about hostname considerations.



NOTE

If you are not using a DHCP service, the cluster nodes obtain their hostname through a reverse DNS lookup.

2. Ensure that your network infrastructure provides the required network connectivity between the cluster components. See the *Networking requirements for user-provisioned infrastructure* section for details about the requirements.

3. Configure your firewall to enable the ports required for the OpenShift Container Platform cluster components to communicate. See *Networking requirements for user-provisioned infrastructure* section for details about the ports that are required.

IMPORTANT

By default, port **1936** is accessible for an OpenShift Container Platform cluster, because each control plane node needs access to this port.

Avoid using the Ingress load balancer to expose this port, because doing so might result in the exposure of sensitive information, such as statistics and metrics, related to Ingress Controllers.

4. Setup the required DNS infrastructure for your cluster.

   a. Configure DNS name resolution for the Kubernetes API, the application wildcard, the bootstrap machine, the control plane machines, and the compute machines.

   b. Configure reverse DNS resolution for the Kubernetes API, the bootstrap machine, the control plane machines, and the compute machines.
   See the *User-provisioned DNS requirements* section for more information about the OpenShift Container Platform DNS requirements.

5. Validate your DNS configuration.

   a. From your installation node, run DNS lookups against the record names of the Kubernetes API, the wildcard routes, and the cluster nodes. Validate that the IP addresses in the responses correspond to the correct components.

   b. From your installation node, run reverse DNS lookups against the IP addresses of the load balancer and the cluster nodes. Validate that the record names in the responses correspond to the correct components.
   See the *Validating DNS resolution for user-provisioned infrastructure* section for detailed DNS validation steps.

6. Provision the required API and application ingress load balancing infrastructure. See the *Load balancing requirements for user-provisioned infrastructure* section for more information about the requirements.

NOTE

Some load balancing solutions require the DNS name resolution for the cluster nodes to be in place before the load balancing is initialized.

Additional resources

- Requirements for a cluster with user-provisioned infrastructure
- Installing RHCOS and starting the OpenShift Container Platform bootstrap process
- Setting the cluster node hostnames through DHCP
- Advanced RHCOS installation configuration
- Networking requirements for user-provisioned infrastructure
- User-provisioned DNS requirements
- Validating DNS resolution for user-provisioned infrastructure
- Load balancing requirements for user-provisioned infrastructure

11.4.6. Validating DNS resolution for user-provisioned infrastructure

You can validate your DNS configuration before installing OpenShift Container Platform on user-provisioned infrastructure.

IMPORTANT

The validation steps detailed in this section must succeed before you install your cluster.

Prerequisites

- You have configured the required DNS records for your user-provisioned infrastructure.

Procedure

1. From your installation node, run DNS lookups against the record names of the Kubernetes API, the wildcard routes, and the cluster nodes. Validate that the IP addresses contained in the responses correspond to the correct components.

   a. Perform a lookup against the Kubernetes API record name. Check that the result points to the IP address of the API load balancer:

   ```
   $ dig +noall +answer @<nameserver_ip> api.<cluster_name>.<base_domain> 1
   ```

   1 Replace **<nameserver_ip>** with the IP address of the nameserver, **<cluster_name>** with your cluster name, and **<base_domain>** with your base domain name.

   Example output

   ```
   api.ocp4.example.com.  604800 IN A 192.168.1.5
   ```

b. Perform a lookup against the Kubernetes internal API record name. Check that the result points to the IP address of the API load balancer:

```
$ dig +noall +answer @<nameserver_ip> api-int.<cluster_name>.<base_domain>
```

Example output

```
api-int.ocp4.example.com.  604800 IN A 192.168.1.5
```

c. Test an example ***.apps.<cluster_name>.<base_domain>** DNS wildcard lookup. All of the application wildcard lookups must resolve to the IP address of the application ingress load balancer:

```
$ dig +noall +answer @<nameserver_ip> random.apps.<cluster_name>.<base_domain>
```

Example output

```
random.apps.ocp4.example.com.  604800 IN A 192.168.1.5
```

NOTE

In the example outputs, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

You can replace **random** with another wildcard value. For example, you can query the route to the OpenShift Container Platform console:

```
$ dig +noall +answer @<nameserver_ip> console-openshift-console.apps.
<cluster_name>.<base_domain>
```

Example output

```
console-openshift-console.apps.ocp4.example.com. 604800 IN A 192.168.1.5
```

d. Run a lookup against the bootstrap DNS record name. Check that the result points to the IP address of the bootstrap node:

```
$ dig +noall +answer @<nameserver_ip> bootstrap.<cluster_name>.<base_domain>
```

Example output

```
bootstrap.ocp4.example.com.  604800 IN A 192.168.1.96
```

e. Use this method to perform lookups against the DNS record names for the control plane and compute nodes. Check that the results correspond to the IP addresses of each node.

2. From your installation node, run reverse DNS lookups against the IP addresses of the load balancer and the cluster nodes. Validate that the record names contained in the responses correspond to the correct components.

a. Perform a reverse lookup against the IP address of the API load balancer. Check that the response includes the record names for the Kubernetes API and the Kubernetes internal API:

```
$ dig +noall +answer @<nameserver_ip> -x 192.168.1.5
```

Example output

```
5.1.168.192.in-addr.arpa. 604800 IN PTR api-int.ocp4.example.com. 1
5.1.168.192.in-addr.arpa. 604800 IN PTR api.ocp4.example.com. 2
```

1 Provides the record name for the Kubernetes internal API.

2 Provides the record name for the Kubernetes API.

NOTE

A PTR record is not required for the OpenShift Container Platform application wildcard. No validation step is needed for reverse DNS resolution against the IP address of the application ingress load balancer.

b. Perform a reverse lookup against the IP address of the bootstrap node. Check that the result points to the DNS record name of the bootstrap node:

```
$ dig +noall +answer @<nameserver_ip> -x 192.168.1.96
```

Example output

```
96.1.168.192.in-addr.arpa. 604800 IN PTR bootstrap.ocp4.example.com.
```

c. Use this method to perform reverse lookups against the IP addresses for the control plane and compute nodes. Check that the results correspond to the DNS record names of each node.

Additional resources

- User-provisioned DNS requirements
- Load balancing requirements for user-provisioned infrastructure

11.4.7. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the **~/.ssh/authorized_keys** list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The **./openshift-install gather** command also requires the SSH public key to be in place on the cluster nodes.

IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.

NOTE

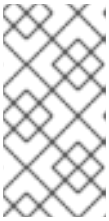
You must use a local key, not one that you configured with platform-specific approaches such as AWS key pairs.

Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N '' -f <path>/<file_name> 1
```

1 Specify the path and file name, such as ~/**.ssh/id_ed25519**, of the new SSH key. If you have an existing key pair, ensure your public key is in the your ~/**.ssh** directory.



NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS validated or Modules In Process cryptographic libraries on the **x86_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the ~/**.ssh/id_ed25519.pub** public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the **./openshift-install gather** command.

NOTE

On some distributions, default SSH private key identities such as ~/**.ssh/id_rsa** and ~/**.ssh/id_dsa** are managed automatically.

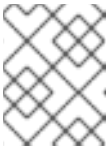
a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
-
```

```
$ eval "$(ssh-agent -s)"
```

Example output

```
Agent pid 31874
```



NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

1 Specify the path and file name for your SSH private key, such as ~/**.ssh/id_ed25519**

Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program. If you install a cluster on infrastructure that you provision, you must provide the key to the installation program.

Additional resources

- Verifying node health

11.4.8. Manually creating the installation configuration file

For user-provisioned installations of OpenShift Container Platform, you manually generate your installation configuration file.

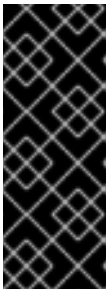
Prerequisites

- You have an SSH public key on your local machine to provide to the installation program. The key will be used for SSH authentication onto your cluster nodes for debugging and disaster recovery.
- You have obtained the OpenShift Container Platform installation program and the pull secret for your cluster.
- Obtain the **imageContentSources** section from the output of the command to mirror the repository.
- Obtain the contents of the certificate for your mirror registry.

Procedure

1. Create an installation directory to store your required installation assets in:

```
$ mkdir <installation_directory>
```



IMPORTANT

You must create a directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

2. Customize the sample **install-config.yaml** file template that is provided and save it in the **<installation_directory>**.

NOTE

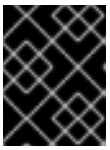
You must name this configuration file **install-config.yaml**.

- Unless you use a registry that RHCOS trusts by default, such as **docker.io**, you must provide the contents of the certificate for your mirror repository in the **additionalTrustBundle** section. In most cases, you must provide the certificate for your mirror.
- You must include the **imageContentSources** section from the output of the command to mirror the repository.

NOTE

For some platform types, you can alternatively run **./openshift-install create install-config --dir <installation_directory>** to generate an **install-config.yaml** file. You can provide details about your cluster configuration at the prompts.

3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.



IMPORTANT

The **install-config.yaml** file is consumed during the next step of the installation process. You must back it up now.

11.4.8.1. Installation configuration parameters

Before you deploy an OpenShift Container Platform cluster, you provide a customized **install-config.yaml** installation configuration file that describes the details for your environment.

NOTE

After installation, you cannot modify these parameters in the **install-config.yaml** file.

11.4.8.1.1. Required configuration parameters

Required installation configuration parameters are described in the following table:

Table 11.42. Required parameters

Parameter	Description	Values
apiVersion	The API version for the **install-config.yaml** content. The current version is **v1**. The installer may also support older API versions.	String
baseDomain	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the **baseDomain** and **metadata.name** parameter values that uses the **<metadata.name>.<baseDomain>** format.	A fully-qualified domain or subdomain name, such as **example.com**.
metadata	Kubernetes resource **ObjectMeta**, from which only the **name** parameter is consumed.	Object
metadata.name	The name of the cluster. DNS records for the cluster are all subdomains of **{{.metadata.name}}.{{.baseDomain}}**.	String of lowercase letters and hyphens (**-**), such as **dev**.
platform	The configuration for the specific platform upon which to perform the installation: **alibabacloud**, **aws**, **baremetal**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**. For additional information about **platform.<platform>** parameters, consult the table for your specific platform that follows.	Object

Parameter	Description	Values
pullSecret	Get a pull secret from the Red Hat OpenShift Cluster Manager to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	<pre>{ "auths":{ "cloud.openshift.com":{ "auth":"b3Blb=", "email":"you@example.com" }, "quay.io":{ "auth":"b3Blb=", "email":"you@example.com" } } }</pre>

11.4.8.1.2. Network configuration parameters

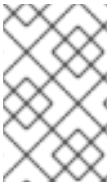
You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

- If you use the OVN-Kubernetes cluster network provider, both IPv4 and IPv6 address families are supported.
- If you use the OpenShift SDN cluster network provider, only the IPv4 address family is supported.

If you configure your cluster to use both IP address families, review the following requirements:

- Both IP families must use the same network interface for the default gateway.
- Both IP families must have the default gateway.
- You must specify IPv4 and IPv6 addresses in the same order for all network configuration parameters. For example, in the following configuration IPv4 addresses are listed before IPv6 addresses.

```
networking:
  clusterNetwork:
  - cidr: 10.128.0.0/14
    hostPrefix: 23
  - cidr: fd00:10:128::/56
    hostPrefix: 64
  serviceNetwork:
  - 172.30.0.0/16
  - fd00:172:16::/112
```



NOTE

Globalnet is not supported with Red Hat OpenShift Data Foundation disaster recovery solutions. For regional disaster recovery scenarios, ensure that you use a nonoverlapping range of private IP addresses for the cluster and service networks in each cluster.

Table 11.43. Network parameters

Parameter	Description	Values
networking	The configuration for the cluster network.	Object  **NOTE** You cannot modify parameters specified by the **networking** object after installation.
networking.networkType	The cluster network provider Container Network Interface (CNI) cluster network provider to install.	Either **OpenShiftSDN** or **OVNKubernetes**. **OpenShiftSDN** is a CNI provider for all-Linux networks. **OVNKubernetes** is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is **OpenShiftSDN**.
networking.clusterNetwork	The IP address blocks for pods. The default value is **10.128.0.0/14** with a host prefix of **/23**. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: `networking:` `  clusterNetwork:` `  - cidr: 10.128.0.0/14` `  hostPrefix: 23` `  - cidr: fd01::/48` `  hostPrefix: 64`
networking.clusterNetwork.cidr	Required if you use **networking.clusterNetwork**. An IP address block. If you use the OpenShift SDN network provider, specify an IPv4 network. If you use the OVN-Kubernetes network provider, you can specify IPv4 and IPv6 networks.	An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between **0** and **32**. The prefix length for an IPv6 block is between **0** and **128**. For example, **10.128.0.0/14** or **fd01::/48**.
networking.clusterNetwork.hostPrefix	The subnet prefix length to assign to each individual node. For example, if **hostPrefix** is set to **23** then each node is assigned a **/23** subnet out of the given **cidr**. A **hostPrefix** value of **23** provides 510 (2^(32 - 23) - 2) pod IP addresses.	A subnet prefix. For an IPv4 network the default value is **23**. For an IPv6 network the default value is **64**. The default value is also the minimum value for IPv6.

Parameter	Description	Values
networking.serviceNetwork	The IP address block for services. The default value is **172.30.0.0/16**. The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network. If you use the OVN-Kubernetes network provider, you can specify an IP address block for both of the IPv4 and IPv6 address families.	An array with an IP address block in CIDR format. For example: `networking:` `  serviceNetwork:` `  - 172.30.0.0/16` `  - fd02::/112`
networking.machineNetwork	The IP address blocks for machines. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: `networking:` `  machineNetwork:` `  - cidr: 10.0.0.0/16`
networking.machineNetwork.cidr	Required if you use **networking.machineNetwork**. An IP address block. The default value is **10.0.0.0/16** for all platforms other than libvirt. For libvirt, the default value is **192.168.126.0/24**.	An IP network block in CIDR notation. For example, **10.0.0.0/16** or **fd00::/48**. **NOTE** Set the **networking.machineNetwork** to match the CIDR that the preferred NIC resides in.

11.4.8.1.3. Optional configuration parameters

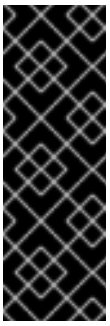
Optional installation configuration parameters are described in the following table:

Table 11.44. Optional parameters

Parameter	Description	Values
additionalTrustBundle	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String

Parameter	Description	Values
capabilities	Controls the installation of optional core cluster components. You can reduce the footprint of your OpenShift Container Platform cluster by disabling optional components.	String array
capabilities.baselineCapabilitySet	Selects an initial set of optional capabilities to enable. Valid values are **None**, **v4.11** and **vCurrent**. **v4.11** enables the **baremetal** Operator, the **marketplace** Operator, and the **openshift-samples** content. **vCurrent** installs the recommended set of capabilities for the current version of OpenShift Container Platform. The default value is **vCurrent**.	String
capabilities.additionalEnabledCapabilities	Extends the set of optional capabilities beyond what you specify in **baselineCapabilitySet**. Valid values are **baremetal**, **marketplace** and **openshift-samples**. You may specify multiple capabilities in this parameter.	String array
cgroupsV2	Enables Linux control groups version 2 (cgroups v2) on specific nodes in your cluster. The OpenShift Container Platform process for enabling cgroups v2 disables all cgroup version 1 controllers and hierarchies. The OpenShift Container Platform cgroups version 2 feature is in Developer Preview and is not supported by Red Hat at this time.	**true**
compute	The configuration for the machines that comprise the compute nodes.	Array of **MachinePool** objects.
compute.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** and **arm64**.	String

Parameter	Description	Values
compute.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  **IMPORTANT** If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
compute.name	Required if you use **compute**. The name of the machine pool.	**worker**
compute.platform	Required if you use **compute**. Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the **controlPlane.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
compute.replicas	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to **2**. The default value is **3**.
controlPlane	The configuration for the machines that comprise the control plane.	Array of **MachinePool** objects.
controlPlane.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** and **arm64**.	String

Parameter	Description	Values
controlPlane.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  IMPORTANT If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
controlPlane.name	Required if you use **controlPlane**. The name of the machine pool.	**master**
controlPlane.platform	Required if you use **controlPlane**. Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the **compute.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
controlPlane.replicas	The number of control plane machines to provision.	The only supported value is **3**, which is the default value.

Parameter	Description	Values
credentialsMode	The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported.  **NOTE** Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the *Cloud Credential Operator* entry in the *Cluster Operators reference* content.  **NOTE** If your AWS account has service control policies (SCP) enabled, you must configure the **credentialsMode** parameter to **Mint**, **Passthrough** or **Manual**.	**Mint**, **Passthrough**, **Manual** or an empty string (**""**).

Parameter	Description	Values
fips	Enable or disable FIPS mode. The default is **false** (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.  **IMPORTANT** To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.  **NOTE** If you are using Azure File storage, you cannot enable FIPS mode.	**false** or **true**
imageContentSources	Sources and repositories for the release-image content.	Array of objects. Includes a **source** and, optionally, **mirrors**, as described in the following rows of this table.
imageContentSources.source	Required if you use **imageContentSources**. Specify the repository that users refer to, for example, in image pull specifications.	String

Parameter	Description	Values
imageContentSources.mirrors	Specify one or more repositories that may also contain the same images.	Array of strings
publish	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	**Internal** or **External**. The default value is **External**. Setting this field to **Internal** is not supported on non-cloud platforms and IBM Cloud VPC.  **IMPORTANT** If the value of the field is set to **Internal**, the cluster will become non-functional. For more information, refer to BZ#1953035.
sshKey	The SSH key to authenticate access to your cluster machines.  **NOTE** For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.	For example, **sshKey: ssh-ed25519 AAAA..**.

11.4.8.2. Sample install-config.yaml file for bare metal

You can customize the **install-config.yaml** file to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.

```
apiVersion: v1
baseDomain: example.com (1)
compute: (2)
- hyperthreading: Enabled (3)
  name: worker
  replicas: 0 (4)
controlPlane: (5)
  hyperthreading: Enabled (6)
  name: master
  replicas: 3 (7)
```

```
metadata:
  name: test 8
networking:
  clusterNetwork:
  - cidr: 10.128.0.0/14 9
    hostPrefix: 23 10
  networkType: OpenShiftSDN
  serviceNetwork: 11
  - 172.30.0.0/16
platform:
  none: {} 12
fips: false 13
pullSecret: '{"auths":{"<local_registry>": {"auth": "<credentials>","email": "you@example.com"}}}' 14
sshKey: 'ssh-ed25519 AAAA...' 15
additionalTrustBundle: | 16
  -----BEGIN CERTIFICATE-----
  ZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZ
  -----END CERTIFICATE-----
imageContentSources: 17
- mirrors:
  - <local_registry>/<local_repository_name>/release
  source: quay.io/openshift-release-dev/ocp-release
- mirrors:
  - <local_registry>/<local_repository_name>/release
  source: quay.io/openshift-release-dev/ocp-v4.0-art-dev
```

1 The base domain of the cluster. All DNS records must be sub-domains of this base and include the cluster name.

2 5 The **controlPlane** section is a single mapping, but the **compute** section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, **-**, and the first line of the **controlPlane** section must not. Only one control plane pool is used.

3 6 Specifies whether to enable or disable simultaneous multithreading (SMT), or hyperthreading. By default, SMT is enabled to increase the performance of the cores in your machines. You can disable it by setting the parameter value to **Disabled**. If you disable SMT, you must disable it in all cluster machines; this includes both control plane and compute machines.

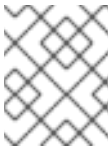
NOTE

Simultaneous multithreading (SMT) is enabled by default. If SMT is not enabled in your BIOS settings, the **hyperthreading** parameter has no effect.

IMPORTANT

If you disable **hyperthreading**, whether in the BIOS or in the **install-config.yaml** file, ensure that your capacity planning accounts for the dramatically decreased machine performance.

4 You must set this value to **0** when you install OpenShift Container Platform on user-provisioned infrastructure. In installer-provisioned installations, the parameter controls the number of compute machines that the cluster creates and manages for you. In user-provisioned installations, you must manually deploy the compute machines before you finish installing the cluster.



NOTE

If you are installing a three-node cluster, do not deploy any compute machines when you install the Red Hat Enterprise Linux CoreOS (RHCOS) machines.

7 The number of control plane machines that you add to the cluster. Because the cluster uses these values as the number of etcd endpoints in the cluster, the value must match the number of control plane machines that you deploy.

8 The cluster name that you specified in your DNS records.

9 A block of IP addresses from which pod IP addresses are allocated. This block must not overlap with existing physical networks. These IP addresses are used for the pod network. If you need to access the pods from an external network, you must configure load balancers and routers to manage the traffic.

NOTE

Class E CIDR range is reserved for a future use. To use the Class E CIDR range, you must ensure your networking environment accepts the IP addresses within the Class E CIDR range.

10 The subnet prefix length to assign to each individual node. For example, if **hostPrefix** is set to **23**, then each node is assigned a /**23** subnet out of the given **cidr**, which allows for 510 (2^(32 - 23) - 2) pod IP addresses. If you are required to provide access to nodes from an external network, configure load balancers and routers to manage the traffic.

11 The IP address pool to use for service IP addresses. You can enter only one IP address pool. This block must not overlap with existing physical networks. If you need to access the services from an external network, configure load balancers and routers to manage the traffic.

12 You must set the platform to **none**. You cannot provide additional platform configuration variables for your platform.

IMPORTANT

Clusters that are installed with the platform type **none** are unable to use some features, such as managing compute machines with the Machine API. This limitation applies even if the compute machines that are attached to the cluster are installed on a platform that would normally support the feature. This parameter cannot be changed after installation.

13 Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.

IMPORTANT

To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.

14 For **<local_registry>**, specify the registry domain name, and optionally the port, that your mirror registry uses to serve content. For example, **registry.example.com** or **registry.example.com:5000**. For **<credentials>**, specify the base64-encoded user name and password for your mirror registry.

15 The SSH public key for the **core** user in Red Hat Enterprise Linux CoreOS (RHCOS).

NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

16 Provide the contents of the certificate file that you used for your mirror registry.

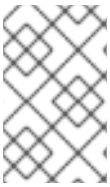
17 Provide the **imageContentSources** section from the output of the command to mirror the repository.

Additional resources

- See Load balancing requirements for user-provisioned infrastructure for more information on the API and application ingress load balancing requirements.

11.4.8.3. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.



NOTE

For bare metal installations, if you do not assign node IP addresses from the range that is specified in the **networking.machineNetwork[].cidr** field in the **install-config.yaml** file, you must include them in the **proxy.noProxy** field.

Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.

NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

Procedure

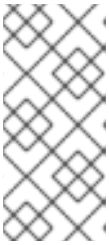
1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
```

1. A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
2. A proxy URL to use for creating HTTPS connections outside the cluster.
3. A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use ***** to bypass the proxy for all destinations.
4. If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace that contains one or more additional CA certificates that are required for proxying HTTPS connections. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges these contents with the Red Hat Enterprise Linux CoreOS (RHCOS) trust bundle, and this config map is referenced in the **trustedCA** field of the **Proxy** object. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.

NOTE

The installation program does not support the proxy **readinessEndpoints** field.



NOTE

If the installer times out, restart and then complete the deployment by using the **wait-for** command of the installer. For example:

```
$ ./openshift-install wait-for install-complete --log-level debug
```

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.

NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

11.4.8.4. Configuring a three-node cluster

Optionally, you can deploy zero compute machines in a bare metal cluster that consists of three control plane machines only. This provides smaller, more resource efficient clusters for cluster administrators and developers to use for testing, development, and production.

In three-node OpenShift Container Platform environments, the three control plane machines are schedulable, which means that your application workloads are scheduled to run on them.

Prerequisites

- You have an existing **install-config.yaml** file.

Procedure

- Ensure that the number of compute replicas is set to **0** in your **install-config.yaml** file, as shown in the following **compute** stanza:

```
compute:
- name: worker
  platform: {}
  replicas: 0
```

NOTE

You must set the value of the **replicas** parameter for the compute machines to **0** when you install OpenShift Container Platform on user-provisioned infrastructure, regardless of the number of compute machines you are deploying. In installer-provisioned installations, the parameter controls the number of compute machines that the cluster creates and manages for you. This does not apply to user-provisioned installations, where the compute machines are deployed manually.

For three-node cluster installations, follow these next steps:

- If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes. See the *Load balancing requirements for user-provisioned infrastructure* section for more information.

- When you create the Kubernetes manifest files in the following procedure, ensure that the **mastersSchedulable** parameter in the **<installation_directory>/manifests/cluster-scheduler-02-config.yml** file is set to **true**. This enables your application workloads to run on the control plane nodes.

- Do not deploy any compute nodes when you create the Red Hat Enterprise Linux CoreOS (RHCOS) machines.

11.4.9. Creating the Kubernetes manifest and Ignition config files

Because you must modify some cluster definition files and manually start the cluster machines, you must generate the Kubernetes manifest and Ignition config files that the cluster needs to configure the machines.

The installation configuration file transforms into the Kubernetes manifests. The manifests wrap into the Ignition configuration files, which are later used to configure the cluster machines.

IMPORTANT

- The Ignition config files that the OpenShift Container Platform installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.

- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

Prerequisites

- You obtained the OpenShift Container Platform installation program. For a restricted network installation, these files are on your mirror host.

- You created the **install-config.yaml** installation configuration file.

Procedure

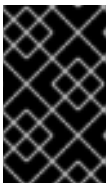
1. Change to the directory that contains the OpenShift Container Platform installation program and generate the Kubernetes manifests for the cluster:

```
$ ./openshift-install create manifests --dir <installation_directory> 1
```

1 For **<installation_directory>**, specify the installation directory that contains the **install-config.yaml** file you created.

WARNING

If you are installing a three-node cluster, skip the following step to allow the control plane nodes to be schedulable.



IMPORTANT

When you configure control plane nodes from the default unschedulable to schedulable, additional subscriptions are required. This is because control plane nodes then become compute nodes.

2. Check that the **mastersSchedulable** parameter in the **<installation_directory>/manifests/cluster-scheduler-02-config.yml** Kubernetes manifest file is set to **false**. This setting prevents pods from being scheduled on the control plane machines:

   a. Open the **<installation_directory>/manifests/cluster-scheduler-02-config.yml** file.

   b. Locate the **mastersSchedulable** parameter and ensure that it is set to **false**.

   c. Save and exit the file.

3. To create the Ignition configuration files, run the following command from the directory that contains the installation program:

```
$ ./openshift-install create ignition-configs --dir <installation_directory> 1
```

1 For **<installation_directory>**, specify the same installation directory.

Ignition config files are created for the bootstrap, control plane, and compute nodes in the installation directory. The **kubeadmin-password** and **kubeconfig** files are created in the **./<installation_directory>/auth** directory:

```
.
├── auth
│   ├── kubeadmin-password
│   └── kubeconfig
├── bootstrap.ign
├── master.ign
├── metadata.json
└── worker.ign
```

Additional resources

- See Recovering from expired control plane certificates for more information about recovering kubelet certificates.

11.4.10. Configuring chrony time service

You must set the time server and related settings used by the chrony time service (**chronyd**) by modifying the contents of the **chrony.conf** file and passing those contents to your nodes as a machine config.

Procedure

1. Create a Butane config including the contents of the **chrony.conf** file. For example, to configure chrony on worker nodes, create a **99-worker-chrony.bu** file.

NOTE

See "Creating machine configs with Butane" for information about Butane.

```
variant: openshift
version: 4.11.0
metadata:
  name: 99-worker-chrony (1)
  labels:
    machineconfiguration.openshift.io/role: worker (2)
storage:
  files:
  - path: /etc/chrony.conf
    mode: 0644 (3)
    overwrite: true
    contents:
      inline: |
        pool 0.rhel.pool.ntp.org iburst (4)
        driftfile /var/lib/chrony/drift
        makestep 1.0 3
        rtcsync
        logdir /var/log/chrony
```

(1) (2) On control plane nodes, substitute **master** for **worker** in both of these locations.

(3) Specify an octal value mode for the **mode** field in the machine config file. After creating the file and applying the changes, the **mode** is converted to a decimal value. You can check the YAML file with the command **oc get mc <mc-name> -o yaml**.

(4) Specify any valid, reachable time source, such as the one provided by your DHCP server.

2. Use Butane to generate a **MachineConfig** object file, **99-worker-chrony.yaml**, containing the configuration to be delivered to the nodes:

```
$ butane 99-worker-chrony.bu -o 99-worker-chrony.yaml
```

3. Apply the configurations in one of two ways:

- If the cluster is not running yet, after you generate manifest files, add the **MachineConfig** object file to the **<installation_directory>/openshift** directory, and then continue to create the cluster.

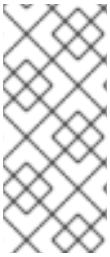
- If the cluster is already running, apply the file:

```
$ oc apply -f ./99-worker-chrony.yaml
```

11.4.11. Installing RHCOS and starting the OpenShift Container Platform bootstrap process

To install OpenShift Container Platform on bare metal infrastructure that you provision, you must install Red Hat Enterprise Linux CoreOS (RHCOS) on the machines. When you install RHCOS, you must provide the Ignition config file that was generated by the OpenShift Container Platform installation program for the type of machine you are installing. If you have configured suitable networking, DNS, and load balancing infrastructure, the OpenShift Container Platform bootstrap process begins automatically after the RHCOS machines have rebooted.

To install RHCOS on the machines, follow either the steps to use an ISO image or network PXE booting.



NOTE

The compute node deployment steps included in this installation document are RHCOS-specific. If you choose instead to deploy RHEL-based compute nodes, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks. Only RHEL 8 compute machines are supported.

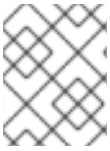
You can configure RHCOS during ISO and PXE installations by using the following methods:

- Kernel arguments: You can use kernel arguments to provide installation-specific information. For example, you can specify the locations of the RHCOS installation files that you uploaded to your HTTP server and the location of the Ignition config file for the type of node you are installing. For a PXE installation, you can use the **APPEND** parameter to pass the arguments to the kernel of the live installer. For an ISO installation, you can interrupt the live installation boot process to add the kernel arguments. In both installation cases, you can use special **coreos.inst.*** arguments to direct the live installer, as well as standard installation boot arguments for turning standard kernel services on or off.

- Ignition configs: OpenShift Container Platform Ignition config files (***.ign**) are specific to the type of node you are installing. You pass the location of a bootstrap, control plane, or compute node Ignition config file during the RHCOS installation so that it takes effect on first boot. In special cases, you can create a separate, limited Ignition config to pass to the live system. That Ignition config could do a certain set of tasks, such as reporting success to a provisioning system after completing installation. This special Ignition config is consumed by the **coreos-installer** to be applied on first boot of the installed system. Do not provide the standard control plane and compute node Ignition configs to the live ISO directly.

- **coreos-installer**: You can boot the live ISO installer to a shell prompt, which allows you to prepare the permanent system in a variety of ways before first boot. In particular, you can run the **coreos-installer** command to identify various artifacts to include, work with disk partitions, and set up networking. In some cases, you can configure features on the live system and copy them to the installed system.

Whether to use an ISO or PXE install depends on your situation. A PXE install requires an available DHCP service and more preparation, but can make the installation process more automated. An ISO install is a more manual process and can be inconvenient if you are setting up more than a few machines.



NOTE

As of OpenShift Container Platform 4.6, the RHCOS ISO and other installation artifacts provide support for installation on disks with 4K sectors.

11.4.11.1. Installing RHCOS by using an ISO image

You can use an ISO image to install RHCOS on the machines.

Prerequisites

- You have created the Ignition config files for your cluster.
- You have configured suitable network, DNS and load balancing infrastructure.
- You have an HTTP server that can be accessed from your computer, and from the machines that you create.
- You have reviewed the *Advanced RHCOS installation configuration* section for different ways to configure features, such as networking and disk partitioning.

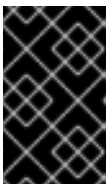
Procedure

1. Obtain the SHA512 digest for each of your Ignition config files. For example, you can use the following on a system running Linux to get the SHA512 digest for your **bootstrap.ign** Ignition config file:

```
$ sha512sum <installation_directory>/bootstrap.ign
```

   The digests are provided to the **coreos-installer** in a later step to validate the authenticity of the Ignition config files on the cluster nodes.

2. Upload the bootstrap, control plane, and compute node Ignition config files that the installation program created to your HTTP server. Note the URLs of these files.



IMPORTANT

You can add or change configuration settings in your Ignition configs before saving them to your HTTP server. If you plan to add more compute machines to your cluster after you finish installation, do not delete these files.

3. From the installation host, validate that the Ignition config files are available on the URLs. The following example gets the Ignition config file for the bootstrap node:

```
$ curl -k http://<HTTP_server>/bootstrap.ign 1
```

   Example output

```
  % Total    % Received % Xferd  Average Speed   Time    Time     Time  Current
                                 Dload  Upload   Total   Spent    Left  Speed
  0     0    0     0    0     0      0      0 --:--:-- --:--:-- --:--:--     0{"ignition":
{"version":"3.2.0"},"passwd":{"users":[{"name":"core","sshAuthorizedKeys":["ssh-rsa...
```

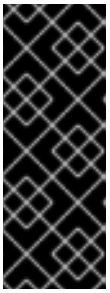
Replace **bootstrap.ign** with **master.ign** or **worker.ign** in the command to validate that the Ignition config files for the control plane and compute nodes are also available.

4. Although it is possible to obtain the RHCOS images that are required for your preferred method of installing operating system instances from the RHCOS image mirror page, the recommended way to obtain the correct version of your RHCOS images are from the output of **openshift-install** command:

```
$ openshift-install coreos print-stream-json | grep '\.iso[^.]'
```

Example output

```
"location": "<url>/art/storage/releases/rhcos-4.11-aarch64/<release>/aarch64/rhcos-
<release>-live.aarch64.iso",
"location": "<url>/art/storage/releases/rhcos-4.11-ppc64le/<release>/ppc64le/rhcos-
<release>-live.ppc64le.iso",
"location": "<url>/art/storage/releases/rhcos-4.11-s390x/<release>/s390x/rhcos-<release>-
live.s390x.iso",
"location": "<url>/art/storage/releases/rhcos-4.11/<release>/x86_64/rhcos-<release>-
live.x86_64.iso",
```



IMPORTANT

The RHCOS images might not change with every release of OpenShift Container Platform. You must download images with the highest version that is less than or equal to the OpenShift Container Platform version that you install. Use the image versions that match your OpenShift Container Platform version if they are available. Use only ISO images for this procedure. RHCOS qcow2 images are not supported for this installation type.

ISO file names resemble the following example:

rhcos-<version>-live.<architecture>.iso

5. Use the ISO to start the RHCOS installation. Use one of the following installation options:
   - Burn the ISO image to a disk and boot it directly.
   - Use ISO redirection by using a lights-out management (LOM) interface.
6. Boot the RHCOS ISO image without specifying any options or interrupting the live boot sequence. Wait for the installer to boot into a shell prompt in the RHCOS live environment.

NOTE

It is possible to interrupt the RHCOS installation boot process to add kernel arguments. However, for this ISO procedure you should use the **coreos-installer** command as outlined in the following steps, instead of adding kernel arguments.

7. Run the **coreos-installer** command and specify the options that meet your installation requirements. At a minimum, you must specify the URL that points to the Ignition config file for the node type, and the device that you are installing to:

```
$ sudo coreos-installer install --ignition-url=http://<HTTP_server>/<node_type>.ign <device>
--ignition-hash=sha512-<digest> 1 2
```

1 1 You must run the **coreos-installer** command by using **sudo**, because the **core** user does not have the required root privileges to perform the installation.

2 The **--ignition-hash** option is required when the Ignition config file is obtained through an HTTP URL to validate the authenticity of the Ignition config file on the cluster node. **<digest>** is the Ignition config file SHA512 digest obtained in a preceding step.

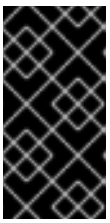
NOTE

If you want to provide your Ignition config files through an HTTPS server that uses TLS, you can add the internal certificate authority (CA) to the system trust store before running **coreos-installer**.

The following example initializes a bootstrap node installation to the **/dev/sda** device. The Ignition config file for the bootstrap node is obtained from an HTTP web server with the IP address 192.168.1.2:

```
$ sudo coreos-installer install --ignition-
url=http://192.168.1.2:80/installation_directory/bootstrap.ign /dev/sda --ignition-hash=sha512-
a5a2d43879223273c9b60af66b44202a1d1248fc01cf156c46d4a79f552b6bad47bc8cc78ddf011
6e80c59d2ea9e32ba53bc807afbca581aa059311def2c3e3b
```

8. Monitor the progress of the RHCOS installation on the console of the machine.



IMPORTANT

Be sure that the installation is successful on each node before commencing with the OpenShift Container Platform installation. Observing the installation process can also help to determine the cause of RHCOS installation issues that might arise.

9. After RHCOS installs, you must reboot the system. During the system reboot, it applies the Ignition config file that you specified.

10. Check the console output to verify that Ignition ran.

Example command

```
Ignition: ran on 2022/03/14 14:48:33 UTC (this boot)
Ignition: user-provided config was applied
```

11. Continue to create the other machines for your cluster.

IMPORTANT

You must create the bootstrap and control plane machines at this time. If the control plane machines are not made schedulable, also create at least two compute machines before you install OpenShift Container Platform.

If the required network, DNS, and load balancer infrastructure are in place, the OpenShift Container Platform bootstrap process begins automatically after the RHCOS nodes have rebooted.

NOTE

RHCOS nodes do not include a default password for the **core** user. You can access the nodes by running **ssh core@<node>.<cluster_name>.<base_domain>** as a user with access to the SSH private key that is paired to the public key that you specified in your **install_config.yaml** file. OpenShift Container Platform 4 cluster nodes running RHCOS are immutable and rely on Operators to apply cluster changes. Accessing cluster nodes by using SSH is not recommended. However, when investigating installation issues, if the OpenShift Container Platform API is not available, or the kubelet is not properly functioning on a target node, SSH access might be required for debugging or disaster recovery.

11.4.11.2. Installing RHCOS by using PXE or iPXE booting

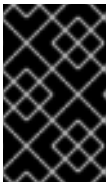
You can use PXE or iPXE booting to install RHCOS on the machines.

Prerequisites

- You have created the Ignition config files for your cluster.
- You have configured suitable network, DNS and load balancing infrastructure.
- You have configured suitable PXE or iPXE infrastructure.
- You have an HTTP server that can be accessed from your computer, and from the machines that you create.
- You have reviewed the *Advanced RHCOS installation configuration* section for different ways to configure features, such as networking and disk partitioning.

Procedure

1. Upload the bootstrap, control plane, and compute node Ignition config files that the installation program created to your HTTP server. Note the URLs of these files.



IMPORTANT

You can add or change configuration settings in your Ignition configs before saving them to your HTTP server. If you plan to add more compute machines to your cluster after you finish installation, do not delete these files.

2. From the installation host, validate that the Ignition config files are available on the URLs. The following example gets the Ignition config file for the bootstrap node:

```
$ curl -k http://<HTTP_server>/bootstrap.ign 1
```

Example output

```
  % Total    % Received % Xferd  Average Speed   Time    Time     Time  Current
```

```
                                 Dload  Upload   Total   Spent    Left  Speed
  0     0    0     0    0     0      0      0 --:--:-- --:--:-- --:--:--     0{"ignition":
{"version":"3.2.0"},"passwd":{"users":[{"name":"core","sshAuthorizedKeys":["ssh-rsa...
```

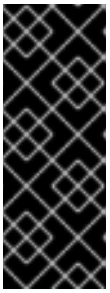
Replace **bootstrap.ign** with **master.ign** or **worker.ign** in the command to validate that the Ignition config files for the control plane and compute nodes are also available.

3. Although it is possible to obtain the RHCOS **kernel**, **initramfs** and **rootfs** files that are required for your preferred method of installing operating system instances from the RHCOS image mirror page, the recommended way to obtain the correct version of your RHCOS files are from the output of **openshift-install** command:

```
$ openshift-install coreos print-stream-json | grep -Eo '"https.*(kernel-|initramfs.|rootfs.)\w+
(\.img)?"'
```

Example output

```
"<url>/art/storage/releases/rhcos-4.11-aarch64/<release>/aarch64/rhcos-<release>-live-
kernel-aarch64"
"<url>/art/storage/releases/rhcos-4.11-aarch64/<release>/aarch64/rhcos-<release>-live-
initramfs.aarch64.img"
"<url>/art/storage/releases/rhcos-4.11-aarch64/<release>/aarch64/rhcos-<release>-live-
rootfs.aarch64.img"
"<url>/art/storage/releases/rhcos-4.11-ppc64le/49.84.202110081256-0/ppc64le/rhcos-
<release>-live-kernel-ppc64le"
"<url>/art/storage/releases/rhcos-4.11-ppc64le/<release>/ppc64le/rhcos-<release>-live-
initramfs.ppc64le.img"
"<url>/art/storage/releases/rhcos-4.11-ppc64le/<release>/ppc64le/rhcos-<release>-live-
rootfs.ppc64le.img"
"<url>/art/storage/releases/rhcos-4.11-s390x/<release>/s390x/rhcos-<release>-live-kernel-
s390x"
"<url>/art/storage/releases/rhcos-4.11-s390x/<release>/s390x/rhcos-<release>-live-
initramfs.s390x.img"
"<url>/art/storage/releases/rhcos-4.11-s390x/<release>/s390x/rhcos-<release>-live-
rootfs.s390x.img"
"<url>/art/storage/releases/rhcos-4.11/<release>/x86_64/rhcos-<release>-live-kernel-
x86_64"
"<url>/art/storage/releases/rhcos-4.11/<release>/x86_64/rhcos-<release>-live-
initramfs.x86_64.img"
"<url>/art/storage/releases/rhcos-4.11/<release>/x86_64/rhcos-<release>-live-
rootfs.x86_64.img"
```



IMPORTANT

The RHCOS artifacts might not change with every release of OpenShift Container Platform. You must download images with the highest version that is less than or equal to the OpenShift Container Platform version that you install. Only use the appropriate **kernel**, **initramfs**, and **rootfs** artifacts described below for this procedure. RHCOS QCOW2 images are not supported for this installation type.

The file names contain the OpenShift Container Platform version number. They resemble the following examples:

- **kernel**: **rhcos-<version>-live-kernel-<architecture>**
- **initramfs**: **rhcos-<version>-live-initramfs.<architecture>.img**
- **rootfs**: **rhcos-<version>-live-rootfs.<architecture>.img**

4. Upload the **rootfs**, **kernel**, and **initramfs** files to your HTTP server.

IMPORTANT

If you plan to add more compute machines to your cluster after you finish installation, do not delete these files.

5. Configure the network boot infrastructure so that the machines boot from their local disks after RHCOS is installed on them.

6. Configure PXE or iPXE installation for the RHCOS images and begin the installation.
Modify one of the following example menu entries for your environment and verify that the image and Ignition files are properly accessible:

- For PXE (**x86_64**):

```
DEFAULT pxeboot
TIMEOUT 20
PROMPT 0
LABEL pxeboot
    KERNEL http://<HTTP_server>/rhcos-<version>-live-kernel-<architecture> 1
    APPEND initrd=http://<HTTP_server>/rhcos-<version>-live-initramfs.
<architecture>.img coreos.live.rootfs_url=http://<HTTP_server>/rhcos-<version>-live-
rootfs.<architecture>.img coreos.inst.install_dev=/dev/sda
coreos.inst.ignition_url=http://<HTTP_server>/bootstrap.ign 2 3
```

1 1 Specify the location of the live **kernel** file that you uploaded to your HTTP server. The URL must be HTTP, TFTP, or FTP; HTTPS and NFS are not supported.

2 If you use multiple NICs, specify a single interface in the **ip** option. For example, to use DHCP on a NIC that is named **eno1**, set **ip=eno1:dhcp**.

3 Specify the locations of the RHCOS files that you uploaded to your HTTP server. The **initrd** parameter value is the location of the **initramfs** file, the **coreos.live.rootfs_url** parameter value is the location of the **rootfs** file, and the **coreos.inst.ignition_url** parameter value is the location of the bootstrap Ignition config file. You can also add more kernel arguments to the **APPEND** line to configure networking or other boot options.

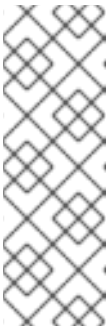
NOTE

This configuration does not enable serial console access on machines with a graphical console. To configure a different console, add one or more **console=** arguments to the **APPEND** line. For example, add **console=tty0 console=ttyS0** to set the first PC serial port as the primary console and the graphical console as a secondary console. For more information, see How does one set up a serial terminal and/or console in Red Hat Enterprise Linux?.

- For iPXE (**x86_64** + **aarch64**):

```
kernel http://<HTTP_server>/rhcos-<version>-live-kernel-<architecture> initrd=main
coreos.live.rootfs_url=http://<HTTP_server>/rhcos-<version>-live-rootfs.
<architecture>.img coreos.inst.install_dev=/dev/sda
coreos.inst.ignition_url=http://<HTTP_server>/bootstrap.ign 1 2
initrd --name main http://<HTTP_server>/rhcos-<version>-live-initramfs.
<architecture>.img 3
boot
```

1. Specify the locations of the RHCOS files that you uploaded to your HTTP server. The **kernel** parameter value is the location of the **kernel** file, the **initrd=main** argument is needed for booting on UEFI systems, the **coreos.live.rootfs_url** parameter value is the location of the **rootfs** file, and the **coreos.inst.ignition_url** parameter value is the location of the bootstrap Ignition config file.
2. If you use multiple NICs, specify a single interface in the **ip** option. For example, to use DHCP on a NIC that is named **eno1**, set **ip=eno1:dhcp**.
3. Specify the location of the **initramfs** file that you uploaded to your HTTP server.



NOTE

This configuration does not enable serial console access on machines with a graphical console. To configure a different console, add one or more **console=** arguments to the **kernel** line. For example, add **console=tty0 console=ttyS0** to set the first PC serial port as the primary console and the graphical console as a secondary console. For more information, see How does one set up a serial terminal and/or console in Red Hat Enterprise Linux?.

NOTE

To network boot the CoreOS **kernel** on **aarch64** architecture, you need to use a version of iPXE build with the **IMAGE_GZIP** option enabled. See **IMAGE_GZIP** option in iPXE .

- For PXE (with UEFI and Grub as second stage) on **aarch64**:

```
menuentry 'Install CoreOS' {
    linux rhcos-<version>-live-kernel-<architecture>
coreos.live.rootfs_url=http://<HTTP_server>/rhcos-<version>-live-rootfs.
<architecture>.img coreos.inst.install_dev=/dev/sda
coreos.inst.ignition_url=http://<HTTP_server>/bootstrap.ign 1 2
    initrd rhcos-<version>-live-initramfs.<architecture>.img 3
}
```

1. Specify the locations of the RHCOS files that you uploaded to your HTTP/TFTP server. The **kernel** parameter value is the location of the **kernel** file on your TFTP server. The **coreos.live.rootfs_url** parameter value is the location of the **rootfs** file, and the **coreos.inst.ignition_url** parameter value is the location of the bootstrap Ignition config file on your HTTP Server.

2 If you use multiple NICs, specify a single interface in the **ip** option. For example, to use DHCP on a NIC that is named **eno1**, set **ip=eno1:dhcp**.

3 Specify the location of the **initramfs** file that you uploaded to your TFTP server.

7. Monitor the progress of the RHCOS installation on the console of the machine.

IMPORTANT

Be sure that the installation is successful on each node before commencing with the OpenShift Container Platform installation. Observing the installation process can also help to determine the cause of RHCOS installation issues that might arise.

8. After RHCOS installs, the system reboots. During reboot, the system applies the Ignition config file that you specified.

9. Check the console output to verify that Ignition ran.

Example command

```
Ignition: ran on 2022/03/14 14:48:33 UTC (this boot)
Ignition: user-provided config was applied
```

10. Continue to create the machines for your cluster.

IMPORTANT

You must create the bootstrap and control plane machines at this time. If the control plane machines are not made schedulable, also create at least two compute machines before you install the cluster.

If the required network, DNS, and load balancer infrastructure are in place, the OpenShift Container Platform bootstrap process begins automatically after the RHCOS nodes have rebooted.

NOTE

RHCOS nodes do not include a default password for the **core** user. You can access the nodes by running **ssh core@<node>.<cluster_name>.<base_domain>** as a user with access to the SSH private key that is paired to the public key that you specified in your **install_config.yaml** file. OpenShift Container Platform 4 cluster nodes running RHCOS are immutable and rely on Operators to apply cluster changes. Accessing cluster nodes by using SSH is not recommended. However, when investigating installation issues, if the OpenShift Container Platform API is not available, or the kubelet is not properly functioning on a target node, SSH access might be required for debugging or disaster recovery.

11.4.11.3. Advanced RHCOS installation configuration

A key benefit for manually provisioning the Red Hat Enterprise Linux CoreOS (RHCOS) nodes for OpenShift Container Platform is to be able to do configuration that is not available through default

OpenShift Container Platform installation methods. This section describes some of the configurations that you can do using techniques that include:

- Passing kernel arguments to the live installer
- Running **coreos-installer** manually from the live system
- Customizing a live ISO or PXE boot image

The advanced configuration topics for manual Red Hat Enterprise Linux CoreOS (RHCOS) installations detailed in this section relate to disk partitioning, networking, and using Ignition configs in different ways.

11.4.11.3.1. Using advanced networking options for PXE and ISO installations

Networking for OpenShift Container Platform nodes uses DHCP by default to gather all necessary configuration settings. To set up static IP addresses or configure special settings, such as bonding, you can do one of the following:

- Pass special kernel parameters when you boot the live installer.
- Use a machine config to copy networking files to the installed system.
- Configure networking from a live installer shell prompt, then copy those settings to the installed system so that they take effect when the installed system first boots.

To configure a PXE or iPXE installation, use one of the following options:

- See the "Advanced RHCOS installation reference" tables.
- Use a machine config to copy networking files to the installed system.

To configure an ISO installation, use the following procedure.

Procedure

1. Boot the ISO installer.
2. From the live system shell prompt, configure networking for the live system using available RHEL tools, such as **nmcli** or **nmtui**.
3. Run the **coreos-installer** command to install the system, adding the **--copy-network** option to copy networking configuration. For example:

```
$ sudo coreos-installer install --copy-network \
    --ignition-url=http://host/worker.ign /dev/sda
```

IMPORTANT

The **--copy-network** option only copies networking configuration found under **/etc/NetworkManager/system-connections**. In particular, it does not copy the system hostname.

4. Reboot into the installed system.

Additional resources

- See Getting started with nmcli and Getting started with nmtui in the RHEL 8 documentation for more information about the **nmcli** and **nmtui** tools.

11.4.11.3.2. Disk partitioning

The disk partitions are created on OpenShift Container Platform cluster nodes during the Red Hat Enterprise Linux CoreOS (RHCOS) installation. Each RHCOS node of a particular architecture uses the same partition layout, unless the default partitioning configuration is overridden. During the RHCOS installation, the size of the root file system is increased to use the remaining available space on the target device.

There are two cases where you might want to override the default partitioning when installing RHCOS on an OpenShift Container Platform cluster node:

- Creating separate partitions: For greenfield installations on an empty disk, you might want to add separate storage to a partition. This is officially supported for mounting **/var** or a subdirectory of **/var**, such as **/var/lib/etcd**, on a separate partition, but not both.

IMPORTANT

For disk sizes larger than 100GB, and especially disk sizes larger than 1TB, create a separate **/var** partition. See "Creating a separate **/var** partition" and this Red Hat Knowledgebase article for more information.

IMPORTANT

Kubernetes supports only two file system partitions. If you add more than one partition to the original configuration, Kubernetes cannot monitor all of them.

- Retaining existing partitions: For a brownfield installation where you are reinstalling OpenShift Container Platform on an existing node and want to retain data partitions installed from your previous operating system, there are both boot arguments and options to **coreos-installer** that allow you to retain existing data partitions.

WARNING

The use of custom partitions could result in those partitions not being monitored by OpenShift Container Platform or alerted on. If you are overriding the default partitioning, see Understanding OpenShift File System Monitoring (eviction conditions) for more information about how OpenShift Container Platform monitors your host file systems.

11.4.11.3.2.1. Creating a separate /var partition

In general, you should use the default disk partitioning that is created during the RHCOS installation. However, there are cases where you might want to create a separate partition for a directory that you expect to grow.

OpenShift Container Platform supports the addition of a single partition to attach storage to either the **/var** directory or a subdirectory of **/var**. For example:

- **/var/lib/containers**: Holds container-related content that can grow as more images and containers are added to a system.
- **/var/lib/etcd**: Holds data that you might want to keep separate for purposes such as performance optimization of etcd storage.
- **/var**: Holds data that you might want to keep separate for purposes such as auditing.

IMPORTANT

For disk sizes larger than 100GB, and especially larger than 1TB, create a separate **/var** partition.

Storing the contents of a **/var** directory separately makes it easier to grow storage for those areas as needed and reinstall OpenShift Container Platform at a later date and keep that data intact. With this method, you will not have to pull all your containers again, nor will you have to copy massive log files when you update systems.

The use of a separate partition for the **/var** directory or a subdirectory of **/var** also prevents data growth in the partitioned directory from filling up the root file system.

The following procedure sets up a separate **/var** partition by adding a machine config manifest that is wrapped into the Ignition config file for a node type during the preparation phase of an installation.

Procedure

1. On your installation host, change to the directory that contains the OpenShift Container Platform installation program and generate the Kubernetes manifests for the cluster:

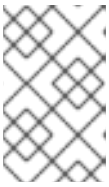
```
$ openshift-install create manifests --dir <installation_directory>
```

2. Create a Butane config that configures the additional partition. For example, name the file **$HOME/clusterconfig/98-var-partition.bu**, change the disk device name to the name of the storage device on the **worker** systems, and set the storage size as appropriate. This example places the **/var** directory on a separate partition:

```
variant: openshift
version: 4.11.0
metadata:
  labels:
    machineconfiguration.openshift.io/role: worker
  name: 98-var-partition
storage:
  disks:
  - device: /dev/<device_name> 1
    partitions:
    - label: var
      start_mib: <partition_start_offset> 2
      size_mib: <partition_size> 3
  filesystems:
    - device: /dev/disk/by-partlabel/var
      path: /var
```

```
    format: xfs
    mount_options: [defaults, prjquota] 4
    with_mount_unit: true
```

1. The storage device name of the disk that you want to partition.
2. When adding a data partition to the boot disk, a minimum offset value of 25000 mebibytes is recommended. The root file system is automatically resized to fill all available space up to the specified offset. If no offset value is specified, or if the specified value is smaller than the recommended minimum, the resulting root file system will be too small, and future reinstalls of RHCOS might overwrite the beginning of the data partition.
3. The size of the data partition in mebibytes.
4. The **prjquota** mount option must be enabled for filesystems used for container storage.



NOTE

When creating a separate /**var** partition, you cannot use different instance types for compute nodes, if the different instance types do not have the same device name.

3. Create a manifest from the Butane config and save it to the **clusterconfig/openshift** directory. For example, run the following command:

```
$ butane $HOME/clusterconfig/98-var-partition.bu -o $HOME/clusterconfig/openshift/98-var-partition.yaml
```

4. Create the Ignition config files:

```
$ openshift-install create ignition-configs --dir <installation_directory> 1
```

1. For **<installation_directory>**, specify the same installation directory.

Ignition config files are created for the bootstrap, control plane, and compute nodes in the installation directory:

```
.
├── auth
│   ├── kubeadmin-password
│   └── kubeconfig
├── bootstrap.ign
├── master.ign
├── metadata.json
└── worker.ign
```

The files in the **<installation_directory>/manifest** and **<installation_directory>/openshift** directories are wrapped into the Ignition config files, including the file that contains the **98-var-partition** custom **MachineConfig** object.

Next steps

- You can apply the custom disk partitioning by referencing the Ignition config files during the RHCOS installations.

11.4.11.3.2.2. Retaining existing partitions

For an ISO installation, you can add options to the **coreos-installer** command that cause the installer to maintain one or more existing partitions. For a PXE installation, you can add **coreos.inst.*** options to the **APPEND** parameter to preserve partitions.

Saved partitions might be data partitions from an existing OpenShift Container Platform system. You can identify the disk partitions you want to keep either by partition label or by number.

NOTE

If you save existing partitions, and those partitions do not leave enough space for RHCOS, the installation will fail without damaging the saved partitions.

Retaining existing partitions during an ISO installation

This example preserves any partition in which the partition label begins with **data** (**data***):

```
# coreos-installer install --ignition-url http://10.0.2.2:8080/user.ign \
      --save-partlabel 'data*' /dev/sda
```

The following example illustrates running the **coreos-installer** in a way that preserves the sixth (6) partition on the disk:

```
# coreos-installer install --ignition-url http://10.0.2.2:8080/user.ign \
      --save-partindex 6 /dev/sda
```

This example preserves partitions 5 and higher:

```
# coreos-installer install --ignition-url http://10.0.2.2:8080/user.ign
      --save-partindex 5- /dev/sda
```

In the previous examples where partition saving is used, **coreos-installer** recreates the partition immediately.

Retaining existing partitions during a PXE installation

This **APPEND** option preserves any partition in which the partition label begins with 'data' ('data*'):

```
coreos.inst.save_partlabel=data*
```

This **APPEND** option preserves partitions 5 and higher:

```
coreos.inst.save_partindex=5-
```

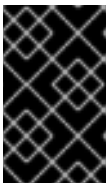
This **APPEND** option preserves partition 6:

```
coreos.inst.save_partindex=6
```

11.4.11.3.3. Identifying Ignition configs

When doing an RHCOS manual installation, there are two types of Ignition configs that you can provide, with different reasons for providing each one:

- **Permanent install Ignition config**: Every manual RHCOS installation needs to pass one of the Ignition config files generated by **openshift-installer**, such as **bootstrap.ign**, **master.ign** and **worker.ign**, to carry out the installation.

  IMPORTANT

  It is not recommended to modify these Ignition config files directly. You can update the manifest files that are wrapped into the Ignition config files, as outlined in examples in the preceding sections.

  For PXE installations, you pass the Ignition configs on the **APPEND** line using the **coreos.inst.ignition_url=** option. For ISO installations, after the ISO boots to the shell prompt, you identify the Ignition config on the **coreos-installer** command line with the **--ignition-url=** option. In both cases, only HTTP and HTTPS protocols are supported.

- **Live install Ignition config**: This type can be created by using the **coreos-installer customize** subcommand and its various options. With this method, the Ignition config passes to the live install medium, runs immediately upon booting, and performs setup tasks before or after the RHCOS system installs to disk. This method should only be used for performing tasks that must be done once and not applied again later, such as with advanced partitioning that cannot be done using a machine config.
  For PXE or ISO boots, you can create the Ignition config and **APPEND** the **ignition.config.url=** option to identify the location of the Ignition config. You also need to append **ignition.firstboot ignition.platform.id=metal** or the **ignition.config.url** option will be ignored.

11.4.11.3.3.1. Customizing a live RHCOS ISO or PXE install

You can use the live ISO image or PXE environment to install RHCOS by injecting an Ignition config file directly into the image. This creates a customized image that you can use to provision your system.

For an ISO image, the mechanism to do this is the **coreos-installer iso customize** subcommand, which modifies the **.iso** file with your configuration. Similarly, the mechanism for a PXE environment is the **coreos-installer pxe customize** subcommand, which creates a new **initramfs** file that includes your customizations.

The **customize** subcommand is a general purpose tool that can embed other types of customizations as well. The following tasks are examples of some of the more common customizations:

- Inject custom CA certificates for when corporate security policy requires their use.
- Configure network settings without the need for kernel arguments.
- Embed arbitrary preinstall and post-install scripts or binaries.

11.4.11.3.3.2. Customizing a live RHCOS ISO image

You can customize a live RHCOS ISO image directly with the **coreos-installer iso customize** subcommand. When you boot the ISO image, the customizations are applied automatically.

You can use this feature to configure the ISO image to automatically install RHCOS.

Procedure

1. Download the **coreos-installer** binary from the **coreos-installer** image mirror page.

2. Retrieve the RHCOS ISO image from the RHCOS image mirror page and the Ignition config file, and then run the following command to inject the Ignition config directly into the ISO image:

```
$ coreos-installer iso customize rhcos-<version>-live.x86_64.iso \
  --dest-ignition bootstrap.ign \ 1
  --dest-device /dev/sda 2
```

1. The Ignition config file that is generated from the **openshift-installer** installation program.

2. When you specify this option, the ISO image automatically runs an installation. Otherwise, the image remains configured for installation, but does not install automatically unless you specify the **coreos.inst.install_dev** kernel argument.

3. Optional: To remove the ISO image customizations and return the image to its pristine state, run:

```
$ coreos-installer iso reset rhcos-<version>-live.x86_64.iso
```

You can now re-customize the live ISO image or use it in its pristine state.

Applying your customizations affects every subsequent boot of RHCOS.

11.4.11.3.3.2.1. Modifying a live install ISO image to use a custom certificate authority

You can provide certificate authority (CA) certificates to Ignition with the **--ignition-ca** flag of the **customize** subcommand. You can use the CA certificates during both the installation boot and when provisioning the installed system.

NOTE

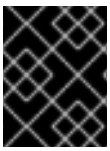
Custom CA certificates affect how Ignition fetches remote resources but they do not affect the certificates installed onto the system.

Procedure

1. Download the **coreos-installer** binary from the **coreos-installer** image mirror page.

2. Retrieve the RHCOS ISO image from the RHCOS image mirror page and run the following command to customize the ISO image for use with a custom CA:

```
$ coreos-installer iso customize rhcos-<version>-live.x86_64.iso --ignition-ca cert.pem
```



IMPORTANT

The **coreos.inst.ignition_url** kernel parameter does not work with the **--ignition-ca** flag. You must use the **--dest-ignition** flag to create a customized image for each cluster.

Applying your custom CA certificate affects every subsequent boot of RHCOS.

11.4.11.3.3.2.2. Modifying a live install ISO image with customized network settings

You can embed a NetworkManager keyfile into the live ISO image and pass it through to the installed system with the **--network-keyfile** flag of the **customize** subcommand.

WARNING

When creating a connection profile, you must use a **.nmconnection** filename extension in the filename of the connection profile. If you do not use a **.nmconnection** filename extension, the cluster will apply the connection profile to the live environment, but it will not apply the configuration when the cluster first boots up the nodes, resulting in a setup that does not work.

Procedure

1. Download the **coreos-installer** binary from the **coreos-installer** image mirror page.
2. Create a connection profile for a bonded interface. For example, create the **bond0.nmconnection** file in your local directory with the following content:

```
[connection]
id=bond0
type=bond
interface-name=bond0
multi-connect=1
permissions=

[ethernet]
mac-address-blacklist=

[bond]
miimon=100
mode=active-backup

[ipv4]
method=auto

[ipv6]
method=auto

[proxy]
```

3. Create a connection profile for a secondary interface to add to the bond. For example, create the **bond0-proxy-em1.nmconnection** file in your local directory with the following content:

```
[connection]
id=em1
type=ethernet
interface-name=em1
master=bond0
multi-connect=1
permissions=
slave-type=bond
```

```
[ethernet]
mac-address-blacklist=
```

4. Create a connection profile for a secondary interface to add to the bond. For example, create the **bond0-proxy-em2.nmconnection** file in your local directory with the following content:

```
[connection]
id=em2
type=ethernet
interface-name=em2
master=bond0
multi-connect=1
permissions=
slave-type=bond

[ethernet]
mac-address-blacklist=
```

5. Retrieve the RHCOS ISO image from the RHCOS image mirror page and run the following command to customize the ISO image with your configured networking:

```
$ coreos-installer iso customize rhcos-<version>-live.x86_64.iso \
    --network-keyfile bond0.nmconnection \
    --network-keyfile bond0-proxy-em1.nmconnection \
    --network-keyfile bond0-proxy-em2.nmconnection
```

Network settings are applied to the live system and are carried over to the destination system.

11.4.11.3.3.3. Customizing a live RHCOS PXE environment

You can customize a live RHCOS PXE environment directly with the **coreos-installer pxe customize** subcommand. When you boot the PXE environment, the customizations are applied automatically.

You can use this feature to configure the PXE environment to automatically install RHCOS.

Procedure

1. Download the **coreos-installer** binary from the **coreos-installer** image mirror page.

2. Retrieve the RHCOS **kernel**, **initramfs** and **rootfs** files from the RHCOS image mirror page and the Ignition config file, and then run the following command to create a new **initramfs** file that contains the customizations from your Ignition config:

```
$ coreos-installer pxe customize rhcos-<version>-live-initramfs.x86_64.img \
    --dest-ignition bootstrap.ign \ 1
    --dest-device /dev/sda \ 2
    -o rhcos-<version>-custom-initramfs.x86_64.img 3
```

1. The Ignition config file that is generated from **openshift-installer**.

2. When you specify this option, the PXE environment automatically runs an install. Otherwise, the image remains configured for installing, but does not do so automatically unless you specify the **coreos.inst.install_dev** kernel argument.

3. Use the customized **initramfs** file in your PXE configuration. Add the **ignition.firstboot** and **ignition.platform.id=metal** kernel arguments if they are not already present.

Applying your customizations affects every subsequent boot of RHCOS.

11.4.11.3.3.3.1. Modifying a live install PXE environment to use a custom certificate authority

You can provide certificate authority (CA) certificates to Ignition with the **--ignition-ca** flag of the **customize** subcommand. You can use the CA certificates during both the installation boot and when provisioning the installed system.

NOTE

Custom CA certificates affect how Ignition fetches remote resources but they do not affect the certificates installed onto the system.

Procedure

1. Download the **coreos-installer** binary from the **coreos-installer** image mirror page.
2. Retrieve the RHCOS **kernel**, **initramfs** and **rootfs** files from the RHCOS image mirror page and run the following command to create a new customized **initramfs** file for use with a custom CA:

```
$ coreos-installer pxe customize rhcos-<version>-live-initramfs.x86_64.img \
    --ignition-ca cert.pem \
    -o rhcos-<version>-custom-initramfs.x86_64.img
```

3. Use the customized **initramfs** file in your PXE configuration. Add the **ignition.firstboot** and **ignition.platform.id=metal** kernel arguments if they are not already present.

IMPORTANT

The **coreos.inst.ignition_url** kernel parameter does not work with the **--ignition-ca** flag. You must use the **--dest-ignition** flag to create a customized image for each cluster.

Applying your custom CA certificate affects every subsequent boot of RHCOS.

11.4.11.3.3.3.2. Modifying a live install PXE environment with customized network settings

You can embed a NetworkManager keyfile into the live PXE environment and pass it through to the installed system with the **--network-keyfile** flag of the **customize** subcommand.

WARNING

When creating a connection profile, you must use a **.nmconnection** filename extension in the filename of the connection profile. If you do not use a **.nmconnection** filename extension, the cluster will apply the connection profile to the live environment, but it will not apply the configuration when the cluster first boots up the nodes, resulting in a setup that does not work.

Procedure

1. Download the **coreos-installer** binary from the **coreos-installer** image mirror page.
2. Create a connection profile for a bonded interface. For example, create the **bond0.nmconnection** file in your local directory with the following content:

```
[connection]
id=bond0
type=bond
interface-name=bond0
multi-connect=1
permissions=

[ethernet]
mac-address-blacklist=

[bond]
miimon=100
mode=active-backup

[ipv4]
method=auto

[ipv6]
method=auto

[proxy]
```

3. Create a connection profile for a secondary interface to add to the bond. For example, create the **bond0-proxy-em1.nmconnection** file in your local directory with the following content:

```
[connection]
id=em1
type=ethernet
interface-name=em1
master=bond0
multi-connect=1
permissions=
slave-type=bond

[ethernet]
mac-address-blacklist=
```

4. Create a connection profile for a secondary interface to add to the bond. For example, create the **bond0-proxy-em2.nmconnection** file in your local directory with the following content:

```
[connection]
id=em2
type=ethernet
interface-name=em2
master=bond0
multi-connect=1
permissions=
slave-type=bond

[ethernet]
mac-address-blacklist=
```

5. Retrieve the RHCOS **kernel**, **initramfs** and **rootfs** files from the RHCOS image mirror page and run the following command to create a new customized **initramfs** file that contains your configured networking:

```
$ coreos-installer pxe customize rhcos-<version>-live-initramfs.x86_64.img \
    --network-keyfile bond0.nmconnection \
    --network-keyfile bond0-proxy-em1.nmconnection \
    --network-keyfile bond0-proxy-em2.nmconnection \
    -o rhcos-<version>-custom-initramfs.x86_64.img
```

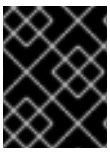
6. Use the customized **initramfs** file in your PXE configuration. Add the **ignition.firstboot** and **ignition.platform.id=metal** kernel arguments if they are not already present.
Network settings are applied to the live system and are carried over to the destination system.

11.4.11.3.4. Advanced RHCOS installation reference

This section illustrates the networking configuration and other advanced options that allow you to modify the Red Hat Enterprise Linux CoreOS (RHCOS) manual installation process. The following tables describe the kernel arguments and command-line options you can use with the RHCOS live installer and the **coreos-installer** command.

11.4.11.3.4.1. Networking and bonding options for ISO installations

If you install RHCOS from an ISO image, you can add kernel arguments manually when you boot the image to configure networking for a node. If no networking arguments are specified, DHCP is activated in the initramfs when RHCOS detects that networking is required to fetch the Ignition config file.



IMPORTANT

When adding networking arguments manually, you must also add the **rd.neednet=1** kernel argument to bring the network up in the initramfs.

The following information provides examples for configuring networking and bonding on your RHCOS nodes for ISO installations. The examples describe how to use the **ip=**, **nameserver=**, and **bond=** kernel arguments.

NOTE

Ordering is important when adding the kernel arguments: **ip=**, **nameserver=**, and then **bond=**.

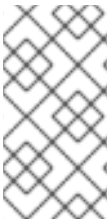
The networking options are passed to the **dracut** tool during system boot. For more information about the networking options supported by **dracut**, see the **dracut.cmdline** manual page.

The following examples are the networking options for ISO installation.

Configuring DHCP or static IP addresses
To configure an IP address, either use DHCP (**ip=dhcp**) or set an individual static IP address (**ip=<host_ip>**). If setting a static IP, you must then identify the DNS server IP address (**nameserver=<dns_ip>**) on each node. The following example sets:

- The node's IP address to **10.10.10.2**
- The gateway address to **10.10.10.254**
- The netmask to **255.255.255.0**
- The hostname to **core0.example.com**
- The DNS server address to **4.4.4.41**
- The auto-configuration value to **none**. No auto-configuration is required when IP networking is configured statically.

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp1s0:none
nameserver=4.4.4.41
```



NOTE

When you use DHCP to configure IP addressing for the RHCOS machines, the machines also obtain the DNS server information through DHCP. For DHCP-based deployments, you can define the DNS server address that is used by the RHCOS nodes through your DHCP server configuration.

Configuring an IP address without a static hostname
You can configure an IP address without assigning a static hostname. If a static hostname is not set by the user, it will be picked up and automatically set by a reverse DNS lookup. To configure an IP address without a static hostname refer to the following example:

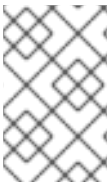
- The node's IP address to **10.10.10.2**
- The gateway address to **10.10.10.254**
- The netmask to **255.255.255.0**
- The DNS server address to **4.4.4.41**
- The auto-configuration value to **none**. No auto-configuration is required when IP networking is configured statically.

```
ip=10.10.10.2::10.10.10.254:255.255.255.0::enp1s0:none
nameserver=4.4.4.41
```

Specifying multiple network interfaces
You can specify multiple network interfaces by setting multiple **ip=** entries.

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp1s0:none
ip=10.10.10.3::10.10.10.254:255.255.255.0:core0.example.com:enp2s0:none
```

Configuring default gateway and route
Optional: You can configure routes to additional networks by setting an **rd.route=** value.



NOTE

When you configure one or multiple networks, one default gateway is required. If the additional network gateway is different from the primary network gateway, the default gateway must be the primary network gateway.

- Run the following command to configure the default gateway:

```
ip=::10.10.10.254::::
```

- Enter the following command to configure the route for the additional network:

```
rd.route=20.20.20.0/24:20.20.20.254:enp2s0
```

Disabling DHCP on a single interface
You can disable DHCP on a single interface, such as when there are two or more network interfaces and only one interface is being used. In the example, the **enp1s0** interface has a static networking configuration and DHCP is disabled for **enp2s0**, which is not used:

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp1s0:none
ip=::::core0.example.com:enp2s0:none
```

Combining DHCP and static IP configurations
You can combine DHCP and static IP configurations on systems with multiple network interfaces, for example:

```
ip=enp1s0:dhcp
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp2s0:none
```

Configuring VLANs on individual interfaces
Optional: You can configure VLANs on individual interfaces by using the **vlan=** parameter.

- To configure a VLAN on a network interface and use a static IP address, run the following command:

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp2s0.100:none
vlan=enp2s0.100:enp2s0
```

- To configure a VLAN on a network interface and to use DHCP, run the following command:

```
ip=enp2s0.100:dhcp
vlan=enp2s0.100:enp2s0
```

Providing multiple DNS servers
You can provide multiple DNS servers by adding a **nameserver=** entry for each server, for example:

```
nameserver=1.1.1.1
nameserver=8.8.8.8
```

Bonding multiple network interfaces to a single interface
Optional: You can bond multiple network interfaces to a single interface by using the **bond=** option. Refer to the following examples:

- The syntax for configuring a bonded interface is: **bond=name[:network_interfaces][:options]**
  name is the bonding device name (**bond0**), *network_interfaces* represents a comma-separated list of physical (ethernet) interfaces (**em1,em2**), and *options* is a comma-separated list of bonding options. Enter **modinfo bonding** to see available options.
- When you create a bonded interface using **bond=**, you must specify how the IP address is assigned and other information for the bonded interface.
- To configure the bonded interface to use DHCP, set the bond's IP address to **dhcp**. For example:

  ```
  bond=bond0:em1,em2:mode=active-backup
  ip=bond0:dhcp
  ```

- To configure the bonded interface to use a static IP address, enter the specific IP address you want and related information. For example:

  ```
  bond=bond0:em1,em2:mode=active-backup
  ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:bond0:none
  ```

Bonding multiple network interfaces to a single interface
Optional: You can configure VLANs on bonded interfaces by using the **vlan=** parameter and to use DHCP, for example:

```
ip=bond0.100:dhcp
bond=bond0:em1,em2:mode=active-backup
vlan=bond0.100:bond0
```

Use the following example to configure the bonded interface with a VLAN and to use a static IP address:

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:bond0.100:none
bond=bond0:em1,em2:mode=active-backup
vlan=bond0.100:bond0
```

Using network teaming
Optional: You can use a network teaming as an alternative to bonding by using the **team=** parameter:

- The syntax for configuring a team interface is: **team=name[:network_interfaces]**
  name is the team device name (**team0**) and *network_interfaces* represents a comma-separated list of physical (ethernet) interfaces (**em1, em2**).

NOTE

Teaming is planned to be deprecated when RHCOS switches to an upcoming version of RHEL. For more information, see this Red Hat Knowledgebase Article .

Use the following example to configure a network team:

```
team=team0:em1,em2
ip=team0:dhcp
```

11.4.11.3.4.2. coreos-installer options for ISO and PXE installations

You can install RHCOS by running **coreos-installer install <options> <device>** at the command prompt, after booting into the RHCOS live environment from an ISO image.

The following table shows the subcommands, options, and arguments you can pass to the **coreos-installer** command.

Table 11.45. coreos-installer subcommands, command-line options, and arguments

coreos-installer install subcommand	
Subcommand	*Description*
$ coreos-installer install <options> <device>	Embed an Ignition config in an ISO image.
coreos-installer install subcommand options	
Option	*Description*
-u, --image-url <url>	Specify the image URL manually.
-f, --image-file <path>	Specify a local image file manually. Used for debugging.
-i, --ignition-file <path>	Embed an Ignition config from a file.
-I, --ignition-url <URL>	Embed an Ignition config from a URL.
--ignition-hash <digest>	Digest **type-value** of the Ignition config.
-p, --platform <name>	Override the Ignition platform ID for the installed system.
--append-karg <arg>…	Append a default kernel argument to the installed system.
--delete-karg <arg>…	Delete a default kernel argument from the installed system.

-n, **--copy-network**	Copy the network configuration from the install environment.  **IMPORTANT** The **--copy-network** option only copies networking configuration found under **/etc/NetworkManager/system-connections**. In particular, it does not copy the system hostname.
--network-dir <path>	For use with **-n**. Default is **/etc/NetworkManager/system-connections/**.
--save-partlabel <lx>..	Save partitions with this label glob.
--save-partindex <id>…	Save partitions with this number or range.
--insecure	Skip RHCOS image signature verification.
--insecure-ignition	Allow Ignition URL without HTTPS or hash.
--architecture <name>	Target CPU architecture. Valid values are **x86_64** and **aarch64**.
--preserve-on-error	Do not clear partition table on error.
-h, **--help**	Print help information.
coreos-installer install subcommand argument	
Argument	*Description*
<device>	The destination device.
coreos-installer ISO subcommands	
Subcommand	*Description*
$ coreos-installer iso customize <options> <ISO_image>	Customize a RHCOS live ISO image.
coreos-installer iso reset <options> <ISO_image>	Restore a RHCOS live ISO image to default settings.

coreos-installer iso ignition remove <options> <ISO_image>	Remove the embedded Ignition config from an ISO image.
coreos-installer ISO customize subcommand options	
Option	*Description*
--dest-ignition <path>	Merge the specified Ignition config file into a new configuration fragment for the destination system.
--dest-device <path>	Install and overwrite the specified destination device.
--dest-karg-append <arg>	Add a kernel argument to each boot of the destination system.
--dest-karg-delete <arg>	Delete a kernel argument from each boot of the destination system.
--network-keyfile <path>	Configure networking by using the specified NetworkManager keyfile for live and destination systems.
--ignition-ca <path>	Specify an additional TLS certificate authority to be trusted by Ignition.
--pre-install <path>	Run the specified script before installation.
--post-install <path>	Run the specified script after installation.
--installer-config <path>	Apply the specified installer configuration file.
--live-ignition <path>	Merge the specified Ignition config file into a new configuration fragment for the live environment.
--live-karg-append <arg>	Add a kernel argument to each boot of the live environment.
--live-karg-delete <arg>	Delete a kernel argument from each boot of the live environment.
--live-karg-replace <k=o=n>	Replace a kernel argument in each boot of the live environment, in the form **key=old=new**.
-f, **--force**	Overwrite an existing Ignition config.
-o, **--output <path>**	Write the ISO to a new output file.
-h, **--help**	Print help information.

coreos-installer PXE subcommands	
Subcommand	*Description*
Note that not all of these options are accepted by all subcommands.	
coreos-installer pxe customize <options> <path>	Customize a RHCOS live PXE boot config.
coreos-installer pxe ignition wrap <options>	Wrap an Ignition config in an image.
coreos-installer pxe ignition unwrap <options> <image_name>	Show the wrapped Ignition config in an image.
coreos-installer PXE customize subcommand options	
Option	*Description*
Note that not all of these options are accepted by all subcommands.	
--dest-ignition <path>	Merge the specified Ignition config file into a new configuration fragment for the destination system.
--dest-device <path>	Install and overwrite the specified destination device.
--network-keyfile <path>	Configure networking by using the specified NetworkManager keyfile for live and destination systems.
--ignition-ca <path>	Specify an additional TLS certificate authority to be trusted by Ignition.
--pre-install <path>	Run the specified script before installation.
post-install <path>	Run the specified script after installation.
--installer-config <path>	Apply the specified installer configuration file.
--live-ignition <path>	Merge the specified Ignition config file into a new configuration fragment for the live environment.
-o, --output <path>	Write the initramfs to a new output file. **NOTE** This option is required for PXE environments.

-h, **--help**	Print help information.

11.4.11.3.4.3. coreos.inst boot options for ISO or PXE installations

You can automatically invoke **coreos-installer** options at boot time by passing **coreos.inst** boot arguments to the RHCOS live installer. These are provided in addition to the standard boot arguments.

- For ISO installations, the **coreos.inst** options can be added by interrupting the automatic boot at the bootloader menu. You can interrupt the automatic boot by pressing **TAB** while the **RHEL CoreOS (Live)** menu option is highlighted.
- For PXE or iPXE installations, the **coreos.inst** options must be added to the **APPEND** line before the RHCOS live installer is booted.

The following table shows the RHCOS live installer **coreos.inst** boot options for ISO and PXE installations.

Table 11.46. coreos.inst boot options

Argument	Description
coreos.inst.install_dev	Required. The block device on the system to install to. It is recommended to use the full path, such as **/dev/sda**, although **sda** is allowed.
coreos.inst.ignition_url	Optional: The URL of the Ignition config to embed into the installed system. If no URL is specified, no Ignition config is embedded. Only HTTP and HTTPS protocols are supported.
coreos.inst.save_partlabel	Optional: Comma-separated labels of partitions to preserve during the install. Glob-style wildcards are permitted. The specified partitions do not need to exist.
coreos.inst.save_partindex	Optional: Comma-separated indexes of partitions to preserve during the install. Ranges **m-n** are permitted, and either **m** or **n** can be omitted. The specified partitions do not need to exist.
coreos.inst.insecure	Optional: Permits the OS image that is specified by **coreos.inst.image_url** to be unsigned.

Argument	Description
coreos.inst.image_url	Optional: Download and install the specified RHCOS image. • This argument should not be used in production environments and is intended for debugging purposes only. • While this argument can be used to install a version of RHCOS that does not match the live media, it is recommended that you instead use the media that matches the version you want to install. • If you are using **coreos.inst.image_url**, you must also use **coreos.inst.insecure**. This is because the bare-metal media are not GPG-signed for OpenShift Container Platform. • Only HTTP and HTTPS protocols are supported.
coreos.inst.skip_reboot	Optional: The system will not reboot after installing. After the install finishes, you will receive a prompt that allows you to inspect what is happening during installation. This argument should not be used in production environments and is intended for debugging purposes only.
coreos.inst.platform_id	Optional: The Ignition platform ID of the platform the RHCOS image is being installed on. Default is **metal**. This option determines whether or not to request an Ignition config from the cloud provider, such as VMware. For example: **coreos.inst.platform_id=vmware**.
ignition.config.url	Optional: The URL of the Ignition config for the live boot. For example, this can be used to customize how **coreos-installer** is invoked, or to run code before or after the installation. This is different from **coreos.inst.ignition_url**, which is the Ignition config for the installed system.

11.4.11.4. Enabling multipathing with kernel arguments on RHCOS

RHCOS supports multipathing on the primary disk, allowing stronger resilience to hardware failure to achieve higher host availability.

You can enable multipathing at installation time for nodes that were provisioned in OpenShift Container Platform 4.8 or later. While postinstallation support is available by activating multipathing via the machine config, enabling multipathing during installation is recommended.

In setups where any I/O to non-optimized paths results in I/O system errors, you must enable multipathing at installation time.

IMPORTANT

On IBM Z and LinuxONE, you can enable multipathing only if you configured your cluster for it during installation. For more information, see "Installing RHCOS and starting the OpenShift Container Platform bootstrap process" in *Installing a cluster with z/VM on IBM Z and LinuxONE*.

The following procedure enables multipath at installation time and appends kernel arguments to the **coreos-installer install** command so that the installed system itself will use multipath beginning from the first boot.

NOTE

OpenShift Container Platform does not support enabling multipathing as a day-2 activity on nodes that have been upgraded from 4.6 or earlier.

Procedure

1. To enable multipath and start the **multipathd** daemon, run the following command:

```
$ mpathconf --enable && systemctl start multipathd.service
```

   - Optional: If booting the PXE or ISO, you can instead enable multipath by adding **rd.multipath=default** from the kernel command line.

2. Append the kernel arguments by invoking the **coreos-installer** program:

   - If there is only one multipath device connected to the machine, it should be available at path **/dev/mapper/mpatha**. For example:

```
$ coreos-installer install /dev/mapper/mpatha \ 1
--append-karg rd.multipath=default \
--append-karg root=/dev/disk/by-label/dm-mpath-root \
--append-karg rw
```

     1 Indicates the path of the single multipathed device.

   - If there are multiple multipath devices connected to the machine, or to be more explicit, instead of using **/dev/mapper/mpatha**, it is recommended to use the World Wide Name (WWN) symlink available in **/dev/disk/by-id**. For example:

```
$ coreos-installer install /dev/disk/by-id/wwn-<wwn_ID> \ 1
--append-karg rd.multipath=default \
--append-karg root=/dev/disk/by-label/dm-mpath-root \
--append-karg rw
```

     1 Indicates the WWN ID of the target multipathed device. For example, **0xx194e957fcedb4841**.

This symlink can also be used as the **coreos.inst.install_dev** kernel argument when using special **coreos.inst.*** arguments to direct the live installer. For more information, see "Installing RHCOS and starting the OpenShift Container Platform bootstrap process".

3. Check that the kernel arguments worked by going to one of the worker nodes and listing the kernel command line arguments (in **/proc/cmdline** on the host):

```
$ oc debug node/ip-10-0-141-105.ec2.internal
```

Example output

```
Starting pod/ip-10-0-141-105ec2internal-debug ...
To use host binaries, run `chroot /host`

sh-4.2# cat /host/proc/cmdline
...
rd.multipath=default root=/dev/disk/by-label/dm-mpath-root
...

sh-4.2# exit
```

You should see the added kernel arguments.

11.4.11.5. Updating the bootloader using bootupd

To update the bootloader by using **bootupd**, you must either install **bootupd** on RHCOS machines manually or provide a machine config with the enabled **systemd** unit. Unlike **grubby** or other bootloader tools, **bootupd** does not manage kernel space configuration such as passing kernel arguments.

After you have installed **bootupd**, you can manage it remotely from the OpenShift Container Platform cluster.

NOTE

It is recommended that you use **bootupd** only on bare metal or virtualized hypervisor installations, such as for protection against the BootHole vulnerability.

Manual install method

You can manually install **bootupd** by using the **bootctl** command-line tool.

1. Inspect the system status:

```
# bootupctl status
```

Example output for x86_64

```
Component EFI
  Installed: grub2-efi-x64-1:2.04-31.fc33.x86_64,shim-x64-15-8.x86_64
  Update: At latest version
```

Example output for aarch64

```
Component EFI
  Installed: grub2-efi-aa64-1:2.02-99.el8_4.1.aarch64,shim-aa64-15.4-2.el8_1.aarch64
  Update: At latest version
```

2. RHCOS images created without **bootupd** installed on them require an explicit adoption phase. If the system status is **Adoptable**, perform the adoption:

```
# bootupctl adopt-and-update
```

Example output

```
Updated: grub2-efi-x64-1:2.04-31.fc33.x86_64,shim-x64-15-8.x86_64
```

3. If an update is available, apply the update so that the changes take effect on the next reboot:

```
# bootupctl update
```

Example output

```
Updated: grub2-efi-x64-1:2.04-31.fc33.x86_64,shim-x64-15-8.x86_64
```

Machine config method

Another way to enable **bootupd** is by providing a machine config.

- Provide a machine config file with the enabled **systemd** unit, as shown in the following example:

Example output

```
variant: rhcos
version: 1.1.0
systemd:
  units:
    - name: custom-bootupd-auto.service
      enabled: true
      contents: |
        [Unit]
        Description=Bootupd automatic update

        [Service]
        ExecStart=/usr/bin/bootupctl update
        RemainAfterExit=yes

        [Install]
        WantedBy=multi-user.target
```

11.4.12. Waiting for the bootstrap process to complete

The OpenShift Container Platform bootstrap process begins after the cluster nodes first boot into the persistent RHCOS environment that has been installed to disk. The configuration information provided through the Ignition config files is used to initialize the bootstrap process and install OpenShift Container Platform on the machines. You must wait for the bootstrap process to complete.

Prerequisites

- You have created the Ignition config files for your cluster.
- You have configured suitable network, DNS and load balancing infrastructure.
- You have obtained the installation program and generated the Ignition config files for your cluster.
- You installed RHCOS on your cluster machines and provided the Ignition config files that the OpenShift Container Platform installation program generated.

Procedure

1. Monitor the bootstrap process:

```
$ ./openshift-install --dir <installation_directory> wait-for bootstrap-complete \ 1
    --log-level=info 2
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

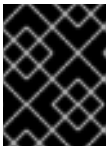
2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

Example output

```
INFO Waiting up to 30m0s for the Kubernetes API at https://api.test.example.com:6443...
INFO API v1.24.0 up
INFO Waiting up to 30m0s for bootstrapping to complete...
INFO It is now safe to remove the bootstrap resources
```

The command succeeds when the Kubernetes API server signals that it has been bootstrapped on the control plane machines.

2. After the bootstrap process is complete, remove the bootstrap machine from the load balancer.



IMPORTANT

You must remove the bootstrap machine from the load balancer at this point. You can also remove or reformat the bootstrap machine itself.

Additional resources

- See Monitoring installation progress for more information about monitoring the installation logs and retrieving diagnostic data if installation issues arise.

11.4.13. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

Example output

```
system:admin
```

11.4.14. Approving the certificate signing requests for your machines

When you add machines to a cluster, two pending certificate signing requests (CSRs) are generated for each machine that you added. You must confirm that these CSRs are approved or, if necessary, approve them yourself. The client requests must be approved first, followed by the server requests.

Prerequisites

- You added machines to your cluster.

Procedure

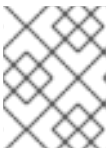
1. Confirm that the cluster recognizes the machines:

```
$ oc get nodes
```

Example output

```
NAME      STATUS    ROLES   AGE  VERSION
master-0  Ready     master  63m  v1.24.0
master-1  Ready     master  63m  v1.24.0
master-2  Ready     master  64m  v1.24.0
```

The output lists all of the machines that you created.



NOTE

The preceding output might not include the compute nodes, also known as worker nodes, until some CSRs are approved.

2. Review the pending CSRs and ensure that you see the client requests with the **Pending** or **Approved** status for each machine that you added to the cluster:

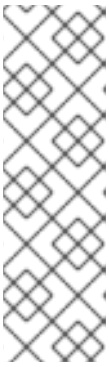
```
$ oc get csr
```

Example output

```
NAME        AGE    REQUESTOR                                                   CONDITION
csr-8b2br   15m    system:serviceaccount:openshift-machine-config-operator:node-bootstrapper   Pending
csr-8vnps   15m    system:serviceaccount:openshift-machine-config-operator:node-bootstrapper   Pending
...
```

In this example, two machines are joining the cluster. You might see more approved CSRs in the list.

3. If the CSRs were not approved, after all of the pending CSRs for the machines you added are in **Pending** status, approve the CSRs for your cluster machines:



NOTE

Because the CSRs rotate automatically, approve your CSRs within an hour of adding the machines to the cluster. If you do not approve them within an hour, the certificates will rotate, and more than two certificates will be present for each node. You must approve all of these certificates. After the client CSR is approved, the Kubelet creates a secondary CSR for the serving certificate, which requires manual approval. Then, subsequent serving certificate renewal requests are automatically approved by the **machine-approver** if the Kubelet requests a new certificate with identical parameters.

NOTE

For clusters running on platforms that are not machine API enabled, such as bare metal and other user-provisioned infrastructure, you must implement a method of automatically approving the kubelet serving certificate requests (CSRs). If a request is not approved, then the **oc exec**, **oc rsh**, and **oc logs** commands cannot succeed, because a serving certificate is required when the API server connects to the kubelet. Any operation that contacts the Kubelet endpoint requires this certificate approval to be in place. The method must watch for new CSRs, confirm that the CSR was submitted by the **node-bootstrapper** service account in the **system:node** or **system:admin** groups, and confirm the identity of the node.

- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

1 **<csr_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{{"\n"}}
{{end}}{{end}}' | xargs --no-run-if-empty oc adm certificate approve
```

NOTE

Some Operators might not become available until some CSRs are approved.

4. Now that your client requests are approved, you must review the server requests for each machine that you added to the cluster:

```
$ oc get csr
```

Example output

```
NAME        AGE     REQUESTOR                                                   CONDITION
csr-bfd72   5m26s   system:node:ip-10-0-50-126.us-east-2.compute.internal
Pending
csr-c57lv   5m26s   system:node:ip-10-0-95-157.us-east-2.compute.internal
Pending
...
```

5. If the remaining CSRs are not approved, and are in the **Pending** status, approve the CSRs for your cluster machines:

- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

1 **<csr_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{{"\n"}}
{{end}}{{end}}' | xargs oc adm certificate approve
```

6. After all client and server CSRs have been approved, the machines have the **Ready** status. Verify this by running the following command:

```
$ oc get nodes
```

Example output

```
NAME      STATUS    ROLES   AGE  VERSION
master-0  Ready     master  73m  v1.24.0
master-1  Ready     master  73m  v1.24.0
master-2  Ready     master  74m  v1.24.0
worker-0  Ready     worker  11m  v1.24.0
worker-1  Ready     worker  11m  v1.24.0
```

NOTE

It can take a few minutes after approval of the server CSRs for the machines to transition to the **Ready** status.

Additional information

- For more information on CSRs, see Certificate Signing Requests.

11.4.15. Initial Operator configuration

After the control plane initializes, you must immediately configure some Operators so that they all become available.

Prerequisites

- Your control plane has initialized.

Procedure

1. Watch the cluster components come online:

```
$ watch -n5 oc get clusteroperators
```

Example output

```
NAME                                       VERSION   AVAILABLE   PROGRESSING   DEGRADED
SINCE
authentication                             4.11.0    True        False         False      19m
baremetal                                  4.11.0    True        False         False      37m
cloud-credential                           4.11.0    True        False         False      40m
cluster-autoscaler                         4.11.0    True        False         False      37m
config-operator                            4.11.0    True        False         False      38m
console                                    4.11.0    True        False         False      26m
csi-snapshot-controller                    4.11.0    True        False         False      37m
dns                                        4.11.0    True        False         False      37m
etcd                                       4.11.0    True        False         False      36m
image-registry                             4.11.0    True        False         False      31m
ingress                                    4.11.0    True        False         False      30m
insights                                   4.11.0    True        False         False      31m
kube-apiserver                             4.11.0    True        False         False      26m
kube-controller-manager                    4.11.0    True        False         False      36m
kube-scheduler                             4.11.0    True        False         False      36m
kube-storage-version-migrator              4.11.0    True        False         False      37m
machine-api                                4.11.0    True        False         False      29m
machine-approver                           4.11.0    True        False         False      37m
machine-config                             4.11.0    True        False         False      36m
marketplace                                4.11.0    True        False         False      37m
monitoring                                 4.11.0    True        False         False      29m
network                                    4.11.0    True        False         False      38m
node-tuning                                4.11.0    True        False         False      37m
openshift-apiserver                        4.11.0    True        False         False      32m
openshift-controller-manager               4.11.0    True        False         False      30m
openshift-samples                          4.11.0    True        False         False      32m
```

```
operator-lifecycle-manager                 4.11.0    True        False         False      37m
operator-lifecycle-manager-catalog         4.11.0    True        False         False      37m
operator-lifecycle-manager-packageserver   4.11.0    True        False         False      32m
service-ca                                 4.11.0    True        False         False      38m
storage                                    4.11.0    True        False         False      37m
```

2. Configure the Operators that are not available.

Additional resources

- See Gathering logs from a failed installation for details about gathering data in the event of a failed OpenShift Container Platform installation.
- See Troubleshooting Operator issues for steps to check Operator pod health across the cluster and gather Operator logs for diagnosis.

11.4.15.1. Disabling the default OperatorHub sources

Operator catalogs that source content provided by Red Hat and community projects are configured for OperatorHub by default during an OpenShift Container Platform installation. In a restricted network environment, you must disable the default catalogs as a cluster administrator.

Procedure

- Disable the sources for the default catalogs by adding **disableAllDefaultSources: true** to the **OperatorHub** object:

```
$ oc patch OperatorHub cluster --type json \
    -p '[{"op": "add", "path": "/spec/disableAllDefaultSources", "value": true}]'
```

TIP

Alternatively, you can use the web console to manage catalog sources. From the **Administration → Cluster Settings → Configuration → OperatorHub** page, click the **Sources** tab, where you can create, update, delete, disable, and enable individual sources.

11.4.15.2. Image registry storage configuration

The Image Registry Operator is not initially available for platforms that do not provide default storage. After installation, you must configure your registry to use storage so that the Registry Operator is made available.

Instructions are shown for configuring a persistent volume, which is required for production clusters. Where applicable, instructions are shown for configuring an empty directory as the storage location, which is available for only non-production clusters.

Additional instructions are provided for allowing the image registry to use block storage types by using the **Recreate** rollout strategy during upgrades.

11.4.15.2.1. Changing the image registry's management state

To start the image registry, you must change the Image Registry Operator configuration's **managementState** from **Removed** to **Managed**.

Procedure

- Change **managementState** Image Registry Operator configuration from **Removed** to **Managed**. For example:

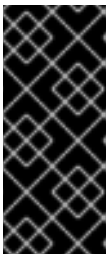
```
$ oc patch configs.imageregistry.operator.openshift.io cluster --type merge --patch '{"spec":{"managementState":"Managed"}}'
```

11.4.15.2.2. Configuring registry storage for bare metal and other manual installations

As a cluster administrator, following installation you must configure your registry to use storage.

Prerequisites

- You have access to the cluster as a user with the **cluster-admin** role.
- You have a cluster that uses manually-provisioned Red Hat Enterprise Linux CoreOS (RHCOS) nodes, such as bare metal.
- You have provisioned persistent storage for your cluster, such as Red Hat OpenShift Data Foundation.



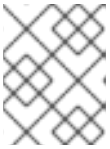
IMPORTANT

OpenShift Container Platform supports **ReadWriteOnce** access for image registry storage when you have only one replica. **ReadWriteOnce** access also requires that the registry uses the **Recreate** rollout strategy. To deploy an image registry that supports high availability with two or more replicas, **ReadWriteMany** access is required.

- Must have 100Gi capacity.

Procedure

1. To configure your registry to use storage, change the **spec.storage.pvc** in the **configs.imageregistry/cluster** resource.



NOTE

When you use shared storage, review your security settings to prevent outside access.

2. Verify that you do not have a registry pod:

```
$ oc get pod -n openshift-image-registry -l docker-registry=default
```

Example output

```
No resourses found in openshift-image-registry namespace
```

NOTE

If you do have a registry pod in your output, you do not need to continue with this procedure.

3. Check the registry configuration:

```
$ oc edit configs.imageregistry.operator.openshift.io
```

Example output

```
storage:
  pvc:
    claim:
```

Leave the **claim** field blank to allow the automatic creation of an **image-registry-storage** PVC.

4. Check the **clusteroperator** status:

```
$ oc get clusteroperator image-registry
```

Example output

```
NAME              VERSION       AVAILABLE   PROGRESSING   DEGRADED   SINCE
MESSAGE
image-registry    4.11          True        False         False      6h50m
```

5. Ensure that your registry is set to managed to enable building and pushing of images.

- Run:

```
$ oc edit configs.imageregistry/cluster
```

Then, change the line

```
managementState: Removed
```

to

```
managementState: Managed
```

11.4.15.2.3. Configuring storage for the image registry in non-production clusters

You must configure storage for the Image Registry Operator. For non-production clusters, you can set the image registry to an empty directory. If you do so, all images are lost if you restart the registry.

Procedure

- To set the image registry storage to an empty directory:

```
$ oc patch configs.imageregistry.operator.openshift.io cluster --type merge --patch '{"spec":
{"storage":{"emptyDir":{}}}}'
```

WARNING

Configure this option for only non-production clusters.

If you run this command before the Image Registry Operator initializes its components, the **oc patch** command fails with the following error:

```
Error from server (NotFound): configs.imageregistry.operator.openshift.io "cluster" not found
```

Wait a few minutes and run the command again.

11.4.15.2.4. Configuring block registry storage for bare metal

To allow the image registry to use block storage types during upgrades as a cluster administrator, you can use the **Recreate** rollout strategy.

IMPORTANT

Block storage volumes, or block persistent volumes, are supported but not recommended for use with the image registry on production clusters. An installation where the registry is configured on block storage is not highly available because the registry cannot have more than one replica.

If you choose to use a block storage volume with the image registry, you must use a filesystem persistent volume claim (PVC).

Procedure

1. Enter the following command to set the image registry storage as a block storage type, patch the registry so that it uses the **Recreate** rollout strategy, and runs with only one (**1**) replica:

```
$ oc patch config.imageregistry.operator.openshift.io/cluster --type=merge -p '{"spec":
{"rolloutStrategy":"Recreate","replicas":1}}'
```

2. Provision the PV for the block storage device, and create a PVC for that volume. The requested block volume uses the ReadWriteOnce (RWO) access mode.

   a. Create a **pvc.yaml** file with the following contents to define a VMware vSphere **PersistentVolumeClaim** object:

```
kind: PersistentVolumeClaim
apiVersion: v1
metadata:
  name: image-registry-storage 1
  namespace: openshift-image-registry 2
spec:
  accessModes:
  - ReadWriteOnce 3
```

```
  resources:
    requests:
      storage: 100Gi 4
```

1. A unique name that represents the **PersistentVolumeClaim** object.
2. The namespace for the **PersistentVolumeClaim** object, which is **openshift-image-registry**.
3. The access mode of the persistent volume claim. With **ReadWriteOnce**, the volume can be mounted with read and write permissions by a single node.
4. The size of the persistent volume claim.

b. Enter the following command to create the **PersistentVolumeClaim** object from the file:

```
$ oc create -f pvc.yaml -n openshift-image-registry
```

3. Enter the following command to edit the registry configuration so that it references the correct PVC:

```
$ oc edit config.imageregistry.operator.openshift.io -o yaml
```

Example output

```
storage:
  pvc:
    claim: 1
```

1. By creating a custom PVC, you can leave the **claim** field blank for the default automatic creation of an **image-registry-storage** PVC.

11.4.16. Completing installation on user-provisioned infrastructure

After you complete the Operator configuration, you can finish installing the cluster on infrastructure that you provide.

Prerequisites

- Your control plane has initialized.
- You have completed the initial Operator configuration.

Procedure

1. Confirm that all the cluster components are online with the following command:

```
$ watch -n5 oc get clusteroperators
```

Example output

```
NAME                                       VERSION   AVAILABLE   PROGRESSING   DEGRADED
SINCE
authentication                             4.11.0    True        False         False      19m
baremetal                                  4.11.0    True        False         False      37m
cloud-credential                           4.11.0    True        False         False      40m
cluster-autoscaler                         4.11.0    True        False         False      37m
config-operator                            4.11.0    True        False         False      38m
console                                    4.11.0    True        False         False      26m
csi-snapshot-controller                    4.11.0    True        False         False      37m
dns                                        4.11.0    True        False         False      37m
etcd                                       4.11.0    True        False         False      36m
image-registry                             4.11.0    True        False         False      31m
ingress                                    4.11.0    True        False         False      30m
insights                                   4.11.0    True        False         False      31m
kube-apiserver                             4.11.0    True        False         False      26m
kube-controller-manager                    4.11.0    True        False         False      36m
kube-scheduler                             4.11.0    True        False         False      36m
kube-storage-version-migrator              4.11.0    True        False         False      37m
machine-api                                4.11.0    True        False         False      29m
machine-approver                           4.11.0    True        False         False      37m
machine-config                             4.11.0    True        False         False      36m
marketplace                                4.11.0    True        False         False      37m
monitoring                                 4.11.0    True        False         False      29m
network                                    4.11.0    True        False         False      38m
node-tuning                                4.11.0    True        False         False      37m
openshift-apiserver                        4.11.0    True        False         False      32m
openshift-controller-manager               4.11.0    True        False         False      30m
openshift-samples                          4.11.0    True        False         False      32m
operator-lifecycle-manager                 4.11.0    True        False         False      37m
operator-lifecycle-manager-catalog         4.11.0    True        False         False      37m
operator-lifecycle-manager-packageserver   4.11.0    True        False         False      32m
service-ca                                 4.11.0    True        False         False      38m
storage                                    4.11.0    True        False         False      37m
```

Alternatively, the following command notifies you when all of the clusters are available. It also retrieves and displays credentials:

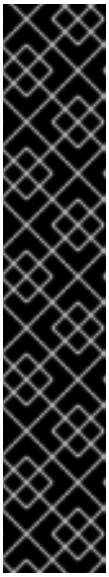
```
$ ./openshift-install --dir <installation_directory> wait-for install-complete 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

Example output

```
INFO Waiting up to 30m0s for the cluster to initialize...
```

The command succeeds when the Cluster Version Operator finishes deploying the OpenShift Container Platform cluster from Kubernetes API server.



IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

2. Confirm that the Kubernetes API server is communicating with the pods.

   a. To view a list of all pods, use the following command:

   ```
   $ oc get pods --all-namespaces
   ```

   Example output

   ```
   NAMESPACE                       NAME                                        READY   STATUS
   RESTARTS   AGE
   openshift-apiserver-operator    openshift-apiserver-operator-85cb746d55-zqhs8   1/1
   Running    1          9m
   openshift-apiserver             apiserver-67b9g                               1/1     Running     0
   3m
   openshift-apiserver             apiserver-ljcmx                               1/1     Running     0
   1m
   openshift-apiserver             apiserver-z25h4                               1/1     Running     0
   2m
   openshift-authentication-operator authentication-operator-69d5d8bf84-vh2n8        1/1
   Running    0          5m
   ...
   ```

   b. View the logs for a pod that is listed in the output of the previous command by using the following command:

   ```
   $ oc logs <pod_name> -n <namespace> 1
   ```

   1 Specify the pod name and namespace, as shown in the output of the previous command.

   If the pod logs display, the Kubernetes API server can communicate with the cluster machines.

3. For an installation with Fibre Channel Protocol (FCP), additional steps are required to enable multipathing. Do not enable multipathing during installation.
   See "Enabling multipathing with kernel arguments on RHCOS" in the *Post-installation machine configuration tasks* documentation for more information.

4. Register your cluster on the Cluster registration page.

11.4.17. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.11, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to OpenShift Cluster Manager Hybrid Cloud Console.

After you confirm that your OpenShift Cluster Manager Hybrid Cloud Console inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, use subscription watch to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

Additional resources

- See About remote health monitoring for more information about the Telemetry service

11.4.18. Next steps

- Validating an installation.
- Customize your cluster.
- Configure image streams for the Cluster Samples Operator and the **must-gather** tool.
- Learn how to use Operator Lifecycle Manager (OLM) on restricted networks .
- If the mirror registry that you used to install your cluster has a trusted CA, add it to the cluster by configuring additional trust stores.
- If necessary, you can opt out of remote health reporting .
- If necessary, see Registering your disconnected cluster

CHAPTER 12. INSTALLING ON-PREMISE WITH ASSISTED INSTALLER

12.1. INSTALLING AN ON-PREMISE CLUSTER USING THE ASSISTED INSTALLER

You can install OpenShift Container Platform on on-premise hardware or on-premise VMs using the Assisted Installer. Installing OpenShift Container Platform using the Assisted Installer supports both x86_64 and AArch64 CPU architectures.

12.1.1. Using the Assisted Installer

The OpenShift Container Platform Assisted Installer is a user-friendly installation solution offered on the Red Hat Hybrid Cloud Console . The Assisted Installer supports the various deployment platforms with a focus on bare metal and vSphere infrastructures.

The Assisted Installer provides installation functionality as a service. This software-as-a-service (SaaS) approach has the following advantages:

- **Web user interface:** The web user interface performs cluster installation without the user having to create the installation configuration files manually.
- **No bootstrap node:** A bootstrap node is not required when installing with the Assisted Installer. The bootstrapping process executes on a node within the cluster.
- **Hosting:** The Assisted Installer hosts:
  - Ignition files
  - The installation configuration
  - A discovery ISO
  - The installer
- **Streamlined installation workflow:** Deployment does not require in-depth knowledge of OpenShift Container Platform. The Assisted Installer provides reasonable defaults and provides the installer as a service, which:
  - Eliminates the need to install and run the OpenShift Container Platform installer locally.
  - Ensures the latest version of the installer up to the latest tested z-stream releases. Older versions remain available, if needed.
  - Enables building automation by using the API without the need to run the OpenShift Container Platform installer locally.
- **Advanced networking:** The Assisted Installer supports IPv4/IPv6 dual stack networking, NMState-based static IP addressing, and an HTTP/S proxy.
- **Preinstallation validation:** The Assisted Installer validates the configuration before installation to ensure a high probability of success. Validation includes:
  - Ensuring network connectivity

    - Ensuring sufficient network bandwidth
    - Ensuring connectivity to the registry
    - Ensuring time synchronization between cluster nodes
    - Verifying that the cluster nodes meet the minimum hardware requirements
    - Validating the installation configuration parameters
- **REST API:** The Assisted Installer has a REST API, enabling automation.

The Assisted Installer supports installing OpenShift Container Platform on premises in a connected environment, including with an optional HTTP/S proxy. It can install the following:

- Highly available OpenShift Container Platform or Single Node OpenShift (SNO)
- OpenShift Container Platform on bare metal or vSphere with full platform integration, or other virtualization platforms without integration
- Optionally OpenShift Virtualization and OpenShift Data Foundation (formerly OpenShift Container Storage)

The user interface provides an intuitive interactive workflow where automation does not exist or is not required. Users may also automate installations using the REST API.

See Install OpenShift with the Assisted Installer to create an OpenShift Container Platform cluster with the Assisted Installer.

12.1.2. API support for the Assisted Installer

Supported APIs for the Assisted Installer are stable for a minimum of three months from the announcement of deprecation.

12.2. PREPARING TO INSTALL WITH THE ASSISTED INSTALLER

Before installing a cluster, you must ensure the cluster nodes and network meet the requirements.

12.2.1. Prerequisites

- You reviewed details about the OpenShift Container Platform installation and update processes.
- You read the documentation on selecting a cluster installation method and preparing it for users.
- If you use a firewall, you must configure it so that Assisted Installer can access the resources it requires to function.

12.2.2. Assisted Installer prerequisites

The Assisted Installer validates the following prerequisites to ensure successful installation.

12.2.2.1. Hardware

For control plane nodes or the single-node OpenShift node, nodes must have at least the following resources:

- 8 CPU cores
- 16.00 GiB RAM
- 100 GB storage
- 10ms write speed or less for etcd **wal_fsync_duration_seconds**

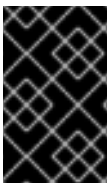
For worker nodes, each node must have at least the following resources:

- 4 CPU cores
- 16.00 GiB RAM
- 100 GB storage

12.2.2.2. Networking

The network must meet the following requirements:

- A DHCP server unless using static IP addressing.
- A base domain name. You must ensure that the following requirements are met:
  - There is no wildcard, such as ***.<cluster_name>.<base_domain>**, or the installation will not proceed.
  - A DNS A/AAAA record for **api.<cluster_name>.<base_domain>**.
  - A DNS A/AAAA record with a wildcard for ***.apps.<cluster_name>.<base_domain>**.
- Port **6443** is open for the API URL if you intend to allow users outside the firewall to access the cluster via the **oc** CLI tool.
- Port **443** is open for the console if you intend to allow users outside the firewall to access the console.



IMPORTANT

DNS A/AAAA record settings at top-level domain registrars can take significant time to update. Ensure the A/AAAA record DNS settings are working before installation to prevent installation delays.

The OpenShift Container Platform cluster's network must also meet the following requirements:

- Connectivity between all cluster nodes
- Connectivity for each node to the internet
- Access to an NTP server for time synchronization between the cluster nodes

12.2.2.3. Preflight validations

The Assisted Installer ensures the cluster meets the prerequisites before installation, because it eliminates complex postinstallation troubleshooting, thereby saving significant amounts of time and effort. Before installing software on the nodes, the Assisted Installer conducts the following validations:

- Ensures network connectivity
- Ensures sufficient network bandwidth
- Ensures connectivity to the registry
- Ensures time synchronization between cluster nodes
- Verifies that the cluster nodes meet the minimum hardware requirements
- Validates the installation configuration parameters

If the Assisted Installer does not successfully validate the foregoing requirements, installation will not proceed.

12.2.3. Additional resources

- Firmware requirements for installing with virtual media
- Increase the network MTU

12.3. INSTALLING WITH THE ASSISTED INSTALLER

After you ensure the cluster nodes and network requirements are met, you can begin installing the cluster.

12.3.1. Preinstallation considerations

Before installing OpenShift Container Platform with the Assisted Installer, you must consider the following configuration choices:

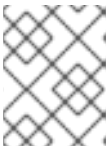
- Which base domain to use
- Which OpenShift Container Platform product version to install
- Whether to install a full cluster or single-node OpenShift
- Whether to use a DHCP server or a static network configuration
- Whether to use IPv4 or dual-stack networking
- Whether to install OpenShift Virtualization
- Whether to install Red Hat OpenShift Data Foundation
- Whether to integrate with vSphere when installing on vSphere

12.3.2. Setting the cluster details

To create a cluster with the Assisted Installer web user interface, use the following procedure.

Procedure

1. Log in to the RedHat Hybrid Cloud Console .
2. In the menu, click **OpenShift**.
3. Click **Create cluster**.
4. Click the **Datacenter** tab.
5. Under the **Assisted Installer** section, select **Create cluster**.
6. Enter a name for the cluster in the **Cluster name** field.
7. Enter a base domain for the cluster in the **Base domain** field. All subdomains for the cluster will use this base domain.



NOTE

The base domain must be a valid DNS name. You must not have a wild card domain set up for the base domain.

8. Select the version of OpenShift Container Platform to install.
9. Optional: Select **Install single node Openshift (SNO)**if you want to install OpenShift Container Platform on a single node.
10. Optional: The Assisted Installer already has the pull secret associated to your account. If you want to use a different pull secret, select **Edit pull secret**
11. Optional: Assisted Installer defaults to using x86_64 CPU architecture. If you are installing OpenShift Container Platform on 64-bit ARM CPUs, select **Use arm64 CPU architecture**. Keep in mind, some features are not available with ARM64 CPU architecture.
12. Optional: If you are using a static IP configuration for the cluster nodes instead of DHCP reservations, select **Static network configuration**.
13. Optional: If you want to enable encryption of the installation disks, select **Enable encryption of installation disks**. For multi-node clusters, you can choose to encrypt the control plane and worker node installation disks separately.

IMPORTANT

You cannot change the base domain, the SNO checkbox, the CPU architecture, the host's network configuration, or the disk-encryption after installation begins.

12.3.3. Optional: Configuring host network interfaces

The Assisted Installer supports IPv4 networking and dual stack networking. The Assisted Installer also supports configuring host network interfaces with the NMState library, a declarative network manager API for hosts. You can use NMState to deploy hosts with static IP addressing, bonds, VLANs and other advanced networking features. If you chose to configure host network interfaces, you must set network-wide configurations. Then, you must create a host-specific configuration for each host and generate the discovery ISO with the host-specific settings.

Procedure

1. Select the internet protocol version. Valid options are **IPv4** and **Dual stack**.
2. If the cluster hosts are on a shared VLAN, enter the VLAN ID.
3. Enter the network-wide IP addresses. If you selected **Dual stack** networking, you must enter both IPv4 and IPv6 addresses.
    a. Enter the cluster network's IP address range in CIDR notation.
    b. Enter the default gateway IP address.
    c. Enter the DNS server IP address.
4. Enter the host-specific configuration.
    a. If you are only setting a static IP address that uses a single network interface, use the form view to enter the IP address and the MAC address for the host.
    b. If you are using multiple interfaces, bonding, or other advanced networking features, use the YAML view and enter the desired network state for the host using NMState syntax.
    c. Add the MAC address and interface name for each interface used in your network configuration.

Additional resources

- NMState version 2.1.4

12.3.4. Adding hosts to the cluster

You must add one or more hosts to the cluster. Adding a host to the cluster involves generating a discovery ISO. The discovery ISO runs Red Hat Enterprise Linux CoreOS (RHCOS) in-memory with an agent. Perform the following procedure for each host on the cluster.

Procedure

1. Click the **Add hosts** button and select the installation media.
    a. Select **Minimal image file: Provision with virtual media** to download a smaller image that will fetch the data needed to boot. The nodes must have virtual media capability. This is the recommended method.
    b. Select **Full image file: Provision with physical media** to download the larger full image.
2. Add an SSH public key so that you can connect to the cluster nodes as the **core** user. Having a login to the cluster nodes can provide you with debugging information during the installation.
3. Optional: If the cluster hosts are behind a firewall that requires the use of a proxy, select **Configure cluster-wide proxy settings**. Enter the username, password, IP address and port for the HTTP and HTTPS URLs of the proxy server.
4. Click **Generate Discovery ISO**.
5. Download the discovery ISO.

12.3.5. Creating an ISO image on a USB drive

You can install software using a USB drive that contains an ISO image. Starting the server with the USB drive prepares the server for the software installation.

Procedure

1. On the administration host, insert a USB drive into a USB port.
2. Create an ISO image on the USB drive, for example:

```
# dd if=<path_to_iso> of=<path_to_usb> status=progress
```

where:

<path_to_iso>
: is the relative path to the downloaded ISO file, for example, **rhcos-live.iso**.

<path_to_usb>
: is the location of the connected USB drive, for example, **/dev/sdb**.
After the ISO is copied to the USB drive, you can use the USB drive to install software on the server.

12.3.6. Booting with a USB drive

To register nodes with the Assisted Installer using a bootable USB drive, use the following procedure.

Procedure

1. Attach the RHCOS discovery ISO to the target host.
2. Configure the boot drive order in the server BIOS settings to boot from the attached discovery ISO, and then reboot the server.
3. On the administration host, return to the browser. Wait for the host to appear in the list of discovered hosts.

12.3.7. Booting from an HTTP-hosted ISO image using the Redfish API

You can provision hosts in your network using ISOs that you install using the Redfish Baseboard Management Controller (BMC) API.

Prerequisites

1. Download the installation Red Hat Enterprise Linux CoreOS (RHCOS) ISO.

Procedure

1. Copy the ISO file to an HTTP server accessible in your network.
2. Boot the host from the hosted ISO file, for example:
   a. Call the redfish API to set the hosted ISO as the **VirtualMedia** boot media by running the following command:

```
$ curl -k -u <bmc_username>:<bmc_password> -d '{"Image":"<hosted_iso_file>",
"Inserted": true}' -H "Content-Type: application/json" -X POST
<host_bmc_address>/redfish/v1/Managers/iDRAC.Embedded.1/VirtualMedia/CD/Actions/Vi
rtualMedia.InsertMedia
```

Where:

<bmc_username>:<bmc_password>

Is the username and password for the target host BMC.

<hosted_iso_file>

Is the URL for the hosted installation ISO, for example: **http://webserver.example.com/rhcos-live-minimal.iso**. The ISO must be accessible from the target host machine.

<host_bmc_address>

Is the BMC IP address of the target host machine.

b. Set the host to boot from the **VirtualMedia** device by running the following command:

```
$ curl -k -u <bmc_username>:<bmc_password> -X PATCH -H 'Content-Type:
application/json' -d '{"Boot": {"BootSourceOverrideTarget": "Cd",
"BootSourceOverrideMode": "UEFI", "BootSourceOverrideEnabled": "Once"}}'
<host_bmc_address>/redfish/v1/Systems/System.Embedded.1
```

c. Reboot the host:

```
$ curl -k -u <bmc_username>:<bmc_password> -d '{"ResetType": "ForceRestart"}' -H
'Content-type: application/json' -X POST
<host_bmc_address>/redfish/v1/Systems/System.Embedded.1/Actions/ComputerSystem.R
eset
```

d. Optional: If the host is powered off, you can boot it using the **{"ResetType": "On"}** switch. Run the following command:

```
$ curl -k -u <bmc_username>:<bmc_password> -d '{"ResetType": "On"}' -H 'Content-
type: application/json' -X POST
<host_bmc_address>/redfish/v1/Systems/System.Embedded.1/Actions/ComputerSystem.R
eset
```

Additional resources

- BMC addressing.
- Firmware requirements for installing with virtual media

12.3.8. Configuring hosts

After booting the hosts with the discovery ISO, the hosts will appear in the table at the bottom of the page. You can configure the hostname, role, and installation disk for each host.

Procedure

1. Select a host.

2. From the **Actions** list, select **Change hostname**. You must ensure each host has a valid and unique hostname. If necessary, enter a new name for the host and click **Change**.

3. For multi-host clusters, in the **Role** column next to the host name, you can click on the menu to change the role of the host.
   If you do not select a role, the Assisted Installer will assign the role automatically. The minimum hardware requirements for control plane nodes exceed that of worker nodes. If you assign a role to a host, ensure that you assign the control plane role to hosts that meet the minimum hardware requirements.

4. To the left of the checkbox next to a host name, click to expand the host details. If you have multiple disk drives, you can select a different disk drive to act as the installation disk.

5. Repeat this procedure for each host.

Once all cluster hosts appear with a status of **Ready**, proceed to the next step.

12.3.9. Configuring networking

Before installing OpenShift Container Platform, you must configure the cluster network.

Procedure

1. In the **Networking** page, select one of the following if it is not already selected for you:

   - **Cluster-Managed Networking:** Selecting cluster-managed networking means that the Assisted Installer will configure a standard network topology, including **keepalived** and Virtual Router Redundancy Protocol (VRRP) for managing the API and Ingress VIP addresses.

   - **User-Managed Networking**: Selecting user-managed networking allows you to deploy OpenShift Container Platform with a non-standard network topology. For example, if you want to deploy with an external load balancer instead of **keepalived** and VRRP, or if you intend to deploy the cluster nodes across many distinct L2 network segments.

2. For cluster-managed networking, configure the following settings:

   a. Define the **Machine network**. You can use the default network or select a subnet.

   b. Define an **API virtual IP**. An API virtual IP provides an endpoint for all users to interact with, and configure the platform.

   c. Define an **Ingress virtual IP**. An Ingress virtual IP provides an endpoint for application traffic flowing from outside the cluster.

3. For user-managed networking, configure the following settings:

   a. Select your **Networking stack type**:

      - **IPv4**: Select this type when your hosts are only using IPv4.

      - **Dual-stack**: You can select dual-stack when your hosts are using IPv4 together with IPv6.

   b. Define the **Machine network**. You can use the default network or select a subnet.

c. Define an **API virtual IP**. An API virtual IP provides an endpoint for all users to interact with, and configure the platform.

d. Define an **Ingress virtual IP**. An Ingress virtual IP provides an endpoint for application traffic flowing from outside the cluster.

e. Optional: You can select **Allocate IPs via DHCP server** to automatically allocate the **API IP** and **Ingress IP** using the DHCP server.

4. Optional: Select **Use advanced networking** to configure the following advanced networking properties:

- **Cluster network CIDR**: Define an IP address block from which Pod IP addresses are allocated.
- **Cluster network host prefix**: Define a subnet prefix length to assign to each node.
- **Service network CIDR**: Define an IP address to use for service IP addresses.
- **Network type**: Select either **Software-Defined Networking (SDN)** for standard networking or **Open Virtual Networking (OVN)** for telco features.

12.3.10. Installing the cluster

After you have completed the configuration and all the nodes are **Ready**, you can begin installation. The installation process takes a considerable amount of time, and you can monitor the installation from the Assisted Installer web console. Nodes will reboot during the installation, and they will initialize after installation.

Procedure

- Press **Begin installation**.

1. Click on the link in the **Status** column of the **Host Inventory** list to see the installation status of a particular host.

12.3.11. Completing the installation

After the cluster is installed and initialized, the Assisted Installer indicates that the installation is finished. The Assisted Installer provides the console URL, the **kubeadmin** username and password, and the **kubeconfig** file. Additionally, the Assisted Installer provides cluster details including the OpenShift Container Platform version, base domain, CPU architecture, API and Ingress IP addresses, and the cluster and service network IP addresses.

Prerequisites

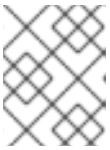
- You have installed the **oc** CLI tool.

Procedure

1. Make a copy of the **kubeadmin** username and password.
2. Download the **kubeconfig** file and copy it to the **auth** directory under your working directory:

```
$ mkdir -p <working_directory>/auth
```

```
$ cp kubeadmin <working_directory>/auth
```



NOTE

The **kubeconfig** file is available for download for 24 hours after completing the installation.

3. Add the **kubeconfig** file to your environment:

```
$ export KUBECONFIG=<your working directory>/auth/kubeconfig
```

4. Login with the **oc** CLI tool:

```
$ oc login -u kubeadmin -p <password>
```

Replace **<password>** with the password of the **kubeadmin** user.

5. Click on the web console URL or click **Launch OpenShift Console** to open the console.
6. Enter the **kubeadmin** username and password. Follow the instructions in the OpenShift Container Platform console to configure an identity provider and configure alert receivers.
7. Add a bookmark of the OpenShift Container Platform console.

12.3.12. Additional resources

- Installing the OpenShift CLI.
- Logging in to the OpenShift CLI
- Creating a cluster admin
- Removing the kubeadmin user

CHAPTER 13. INSTALLING ON A SINGLE NODE

13.1. PREPARING TO INSTALL ON A SINGLE NODE

13.1.1. Prerequisites

- You reviewed details about the OpenShift Container Platform installation and update processes.
- You have read the documentation on selecting a cluster installation method and preparing it for users.

13.1.2. About OpenShift on a single node

You can create a single-node cluster with standard installation methods. OpenShift Container Platform on a single node is a specialized installation that requires the creation of a special ignition configuration ISO. The primary use case is for edge computing workloads, including intermittent connectivity, portable clouds, and 5G radio access networks (RAN) close to a base station. The major tradeoff with an installation on a single node is the lack of high availability.

IMPORTANT

The use of OpenShiftSDN with single-node OpenShift is not supported. OVN-Kubernetes is the default networking solution for single-node OpenShift deployments.

13.1.3. Requirements for installing OpenShift on a single node

Installing OpenShift Container Platform on a single node alleviates some of the requirements for high availability and large scale clusters. However, you must address the following requirements:

- **Administration host:** You must have a computer to prepare the ISO, to create the USB boot drive, and to monitor the installation.
- **Supported platforms:** Installing OpenShift Container Platform on a single node is supported on bare metal and Certified third-party hypervisors. In all cases, you must specify the **platform.none: {}** parameter in the **install-config.yaml** configuration file.
- **Production-grade server:** Installing OpenShift Container Platform on a single node requires a server with sufficient resources to run OpenShift Container Platform services and a production workload.

Table 13.1. Minimum resource requirements

Profile	vCPU	Memory	Storage
Minimum	8 vCPU cores	16GB of RAM	120GB

NOTE

One vCPU is equivalent to one physical core when simultaneous multithreading (SMT), or hyperthreading, is not enabled. When enabled, use the following formula to calculate the corresponding ratio:

(threads per core × cores) × sockets = vCPUs

The server must have a Baseboard Management Controller (BMC) when booting with virtual media.

- **Networking:** The server must have access to the internet or access to a local registry if it is not connected to a routable network. The server must have a DHCP reservation or a static IP address for the Kubernetes API, ingress route, and cluster node domain names. You must configure the DNS to resolve the IP address to each of the following fully qualified domain names (FQDN):

  Table 13.2. Required DNS records

Usage	FQDN	Description
Kubernetes API	**api.<cluster_name>.<base_domain>**	Add a DNS A/AAAA or CNAME record. This record must be resolvable by clients external to the cluster.
Internal API	**api-int.<cluster_name>.<base_domain>**	Add a DNS A/AAAA or CNAME record when creating the ISO manually. This record must be resolvable by nodes within the cluster.
Ingress route	***.apps.<cluster_name>.<base_domain>**	Add a wildcard DNS A/AAAA or CNAME record that targets the node. This record must be resolvable by clients external to the cluster.

  Without persistent IP addresses, communications between the **apiserver** and **etcd** might fail.

13.2. INSTALLING OPENSHIFT ON A SINGLE NODE

You can install single-node OpenShift using the web-based Assisted Installer and a discovery ISO that you generate using the Assisted Installer. You can also install single-node OpenShift by using **coreos-installer** to generate the installation ISO.

13.2.1. Installing single-node OpenShift using the Assisted Installer

To install OpenShift Container Platform on a single node, use the web-based Assisted Installer wizard to guide you through the process and manage the installation.

13.2.1.1. Generating the discovery ISO with the Assisted Installer

Installing OpenShift Container Platform on a single node requires a discovery ISO, which the Assisted Installer can generate.

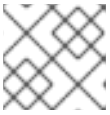
Procedure

1. On the administration host, open a browser and navigate to Red Hat OpenShift Cluster Manager.
2. Click **Create Cluster** to create a new cluster.
3. In the **Cluster name** field, enter a name for the cluster.
4. In the **Base domain** field, enter a base domain. For example:

   ```
   example.com
   ```

   All DNS records must be subdomains of this base domain and include the cluster name, for example:

   ```
   <cluster-name>.example.com
   ```

   NOTE

   You cannot change the base domain or cluster name after cluster installation.

5. Select **Install single node OpenShift (SNO)** and complete the rest of the wizard steps. Download the discovery ISO.
6. Make a note of the discovery ISO URL for installing with virtual media.

NOTE

If you enable OpenShift Virtualization during this process, you must have a second local storage device of at least 50GiB for your virtual machines.

Additional resources

- What you can do with OpenShift Virtualization

13.2.1.2. Installing single-node OpenShift with the Assisted Installer

Use the Assisted Installer to install the single-node cluster.

Procedure

1. Attach the RHCOS discovery ISO to the target host.
2. Configure the boot drive order in the server BIOS settings to boot from the attached discovery ISO and then reboot the server.
3. On the administration host, return to the browser. Wait for the host to appear in the list of discovered hosts. If necessary, reload the **Assisted Clusters** page and select the cluster name.

4. Complete the install wizard steps. Add networking details, including a subnet from the available subnets. Add the SSH public key if necessary.

5. Monitor the installation's progress. Watch the cluster events. After the installation process finishes writing the operating system image to the server's hard disk, the server restarts.

6. Remove the discovery ISO, and reset the server to boot from the installation drive. The server restarts several times automatically, deploying the control plane.

Additional resources

- Creating a bootable ISO image on a USB drive
- Booting from an HTTP-hosted ISO image using the Redfish API
- Adding worker nodes to single-node OpenShift clusters

13.2.2. Installing single-node OpenShift manually

To install OpenShift Container Platform on a single node, first generate the installation ISO, and then boot the server from the ISO. You can monitor the installation using the **openshift-install** installation program.

13.2.2.1. Generating the installation ISO with coreos-installer

Installing OpenShift Container Platform on a single node requires an installation ISO, which you can generate with the following procedure.

Prerequisites

- Install **podman**.

Procedure

1. Set the OpenShift Container Platform version:

```
$ OCP_VERSION=<ocp_version> 1
```

1 Replace **<ocp_version>** with the current version, for example, **latest-4.11**

2. Set the host architecture:

```
$ ARCH=<architecture> 1
```

1 Replace **<architecture>** with the target host architecture, for example, **aarch64** or **x86_64**.

3. Download the OpenShift Container Platform client (**oc**) and make it available for use by entering the following commands:

```
$ curl -k https://mirror.openshift.com/pub/openshift-
v4/clients/ocp/$OCP_VERSION/openshift-client-linux.tar.gz -o oc.tar.gz
```

```
$ tar zxf oc.tar.gz
```

```
$ chmod +x oc
```

4. Download the OpenShift Container Platform installer and make it available for use by entering the following commands:

```
$ curl -k https://mirror.openshift.com/pub/openshift-v4/clients/ocp/$OCP_VERSION/openshift-install-linux.tar.gz -o openshift-install-linux.tar.gz
```

```
$ tar zxvf openshift-install-linux.tar.gz
```

```
$ chmod +x openshift-install
```

5. Retrieve the RHCOS ISO URL by running the following command:

```
$ ISO_URL=$(./openshift-install coreos print-stream-json | grep location | grep $ARCH | grep iso | cut -d\" -f4)
```

6. Download the RHCOS ISO:

```
$ curl -L $ISO_URL -o rhcos-live.iso
```

7. Prepare the **install-config.yaml** file:

```
apiVersion: v1
baseDomain: <domain> (1)
compute:
- name: worker
  replicas: 0 (2)
controlPlane:
  name: master
  replicas: 1 (3)
metadata:
  name: <name> (4)
networking: (5)
  clusterNetwork:
  - cidr: 10.128.0.0/14
    hostPrefix: 23
  machineNetwork:
  - cidr: 10.0.0.0/16 (6)
  networkType: OVNKubernetes
  serviceNetwork:
  - 172.30.0.0/16
platform:
  none: {}
bootstrapInPlace:
  installationDisk: /dev/disk/by-id/<disk_id> (7)
pullSecret: '<pull_secret>' (8)
sshKey: |
  <ssh_key> (9)
```

1. Add the cluster domain name.
2. Set the **compute** replicas to **0**. This makes the control plane node schedulable.
3. Set the **controlPlane** replicas to **1**. In conjunction with the previous **compute** setting, this setting ensures the cluster runs on a single node.
4. Set the **metadata** name to the cluster name.
5. Set the **networking** details. OVN-Kubernetes is the only allowed networking type for single-node clusters.
6. Set the **cidr** value to match the subnet of the single-node OpenShift cluster.
7. Set the path to the installation disk drive, for example, **/dev/disk/by-id/wwn-0x64cd98f04fde100024684cf3034da5c2**.
8. Copy the pull secret from the Red Hat OpenShift Cluster Manager and add the contents to this configuration setting.
9. Add the public SSH key from the administration host so that you can log in to the cluster after installation.

8. Generate OpenShift Container Platform assets by running the following commands:

```
$ mkdir ocp
```

```
$ cp install-config.yaml ocp
```

```
$ ./openshift-install --dir=ocp create single-node-ignition-config
```

9. Embed the ignition data into the RHCOS ISO by running the following commands:

```
$ alias coreos-installer='podman run --privileged --pull always --rm \
      -v /dev:/dev -v /run/udev:/run/udev -v $PWD:/data \
      -w /data quay.io/coreos/coreos-installer:release'
```

```
$ coreos-installer iso ignition embed -fi ocp/bootstrap-in-place-for-live-iso.ign rhcos-live.iso
```

13.2.2.2. Monitoring the cluster installation using openshift-install

Use **openshift-install** to monitor the progress of the single-node cluster installation.

Procedure

1. Attach the modified RHCOS installation ISO to the target host.
2. Configure the boot drive order in the server BIOS settings to boot from the attached discovery ISO and then reboot the server.
3. On the administration host, monitor the installation by running the following command:

```
$ ./openshift-install --dir=ocp wait-for install-complete
```

The server restarts several times while deploying the control plane.

Verification

- After the installation is complete, check the environment by running the following command:

```
$ export KUBECONFIG=ocp/auth/kubeconfig
```

```
$ oc get nodes
```

Example output

```
NAME                         STATUS   ROLES          AGE     VERSION
control-plane.example.com    Ready    master,worker   10m     v1.24.0+beaaed6
```

Additional resources

- Creating a bootable ISO image on a USB drive
- Booting from an HTTP-hosted ISO image using the Redfish API
- Adding worker nodes to single-node OpenShift clusters

13.2.3. Creating a bootable ISO image on a USB drive

You can install software using a bootable USB drive that contains an ISO image. Booting the server with the USB drive prepares the server for the software installation.

Procedure

1. On the administration host, insert a USB drive into a USB port.
2. Create a bootable USB drive, for example:

```
# dd if=<path_to_iso> of=<path_to_usb> status=progress
```

where:

<path_to_iso>
: is the relative path to the downloaded ISO file, for example, **rhcos-live.iso**.

<path_to_usb>
: is the location of the connected USB drive, for example, **/dev/sdb**.

After the ISO is copied to the USB drive, you can use the USB drive to install software on the server.

13.2.4. Booting from an HTTP-hosted ISO image using the Redfish API

You can provision hosts in your network using ISOs that you install using the Redfish Baseboard Management Controller (BMC) API.

Prerequisites

1. Download the installation Red Hat Enterprise Linux CoreOS (RHCOS) ISO.

Procedure

1. Copy the ISO file to an HTTP server accessible in your network.
2. Boot the host from the hosted ISO file, for example:
   a. Call the redfish API to set the hosted ISO as the **VirtualMedia** boot media by running the following command:

```
$ curl -k -u <bmc_username>:<bmc_password> -d '{"Image":"<hosted_iso_file>",
"Inserted": true}' -H "Content-Type: application/json" -X POST
<host_bmc_address>/redfish/v1/Managers/iDRAC.Embedded.1/VirtualMedia/CD/Actions/Vi
rtualMedia.InsertMedia
```

   Where:

   <bmc_username>:<bmc_password>

   Is the username and password for the target host BMC.

   <hosted_iso_file>

   Is the URL for the hosted installation ISO, for example: **http://webserver.example.com/rhcos-live-minimal.iso**. The ISO must be accessible from the target host machine.

   <host_bmc_address>

   Is the BMC IP address of the target host machine.

   b. Set the host to boot from the **VirtualMedia** device by running the following command:

```
$ curl -k -u <bmc_username>:<bmc_password> -X PATCH -H 'Content-Type:
application/json' -d '{"Boot": {"BootSourceOverrideTarget": "Cd",
"BootSourceOverrideMode": "UEFI", "BootSourceOverrideEnabled": "Once"}}'
<host_bmc_address>/redfish/v1/Systems/System.Embedded.1
```

   c. Reboot the host:

```
$ curl -k -u <bmc_username>:<bmc_password> -d '{"ResetType": "ForceRestart"}' -H
'Content-type: application/json' -X POST
<host_bmc_address>/redfish/v1/Systems/System.Embedded.1/Actions/ComputerSystem.R
eset
```

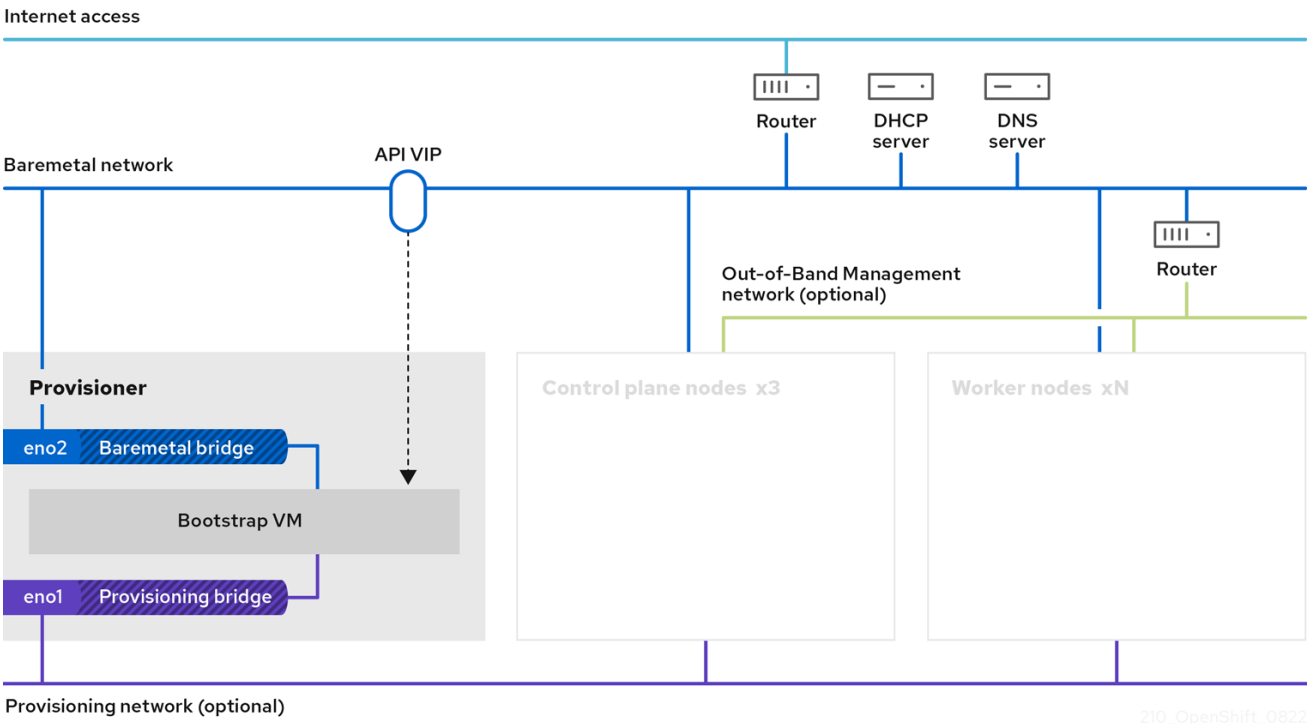
   d. Optional: If the host is powered off, you can boot it using the **{"ResetType": "On"}** switch. Run the following command:

```
$ curl -k -u <bmc_username>:<bmc_password> -d '{"ResetType": "On"}' -H 'Content-
type: application/json' -X POST
<host_bmc_address>/redfish/v1/Systems/System.Embedded.1/Actions/ComputerSystem.R
eset
```

CHAPTER 14. DEPLOYING INSTALLER-PROVISIONED CLUSTERS ON BARE METAL

14.1. OVERVIEW

Installer-provisioned installation on bare metal nodes deploys and configures the infrastructure that an OpenShift Container Platform cluster runs on. This guide provides a methodology to achieving a successful installer-provisioned bare-metal installation. The following diagram illustrates the installation environment in phase 1 of deployment:



For the installation, the key elements in the previous diagram are:

- **Provisioner**: A physical machine that runs the installation program and hosts the bootstrap VM that deploys the control plane of a new OpenShift Container Platform cluster.
- **Bootstrap VM**: A virtual machine used in the process of deploying an OpenShift Container Platform cluster.
- **Network bridges**: The bootstrap VM connects to the bare metal network and to the provisioning network, if present, via network bridges, **eno1** and **eno2**.
- **API VIP**: An API virtual IP address (VIP) is used to provide failover of the API server across the control plane nodes. The API VIP first resides on the bootstrap VM. A script generates the **keepalived.conf** configuration file before launching the service. The VIP moves to one of the control plane nodes after the bootstrap process has completed and the bootstrap VM stops.

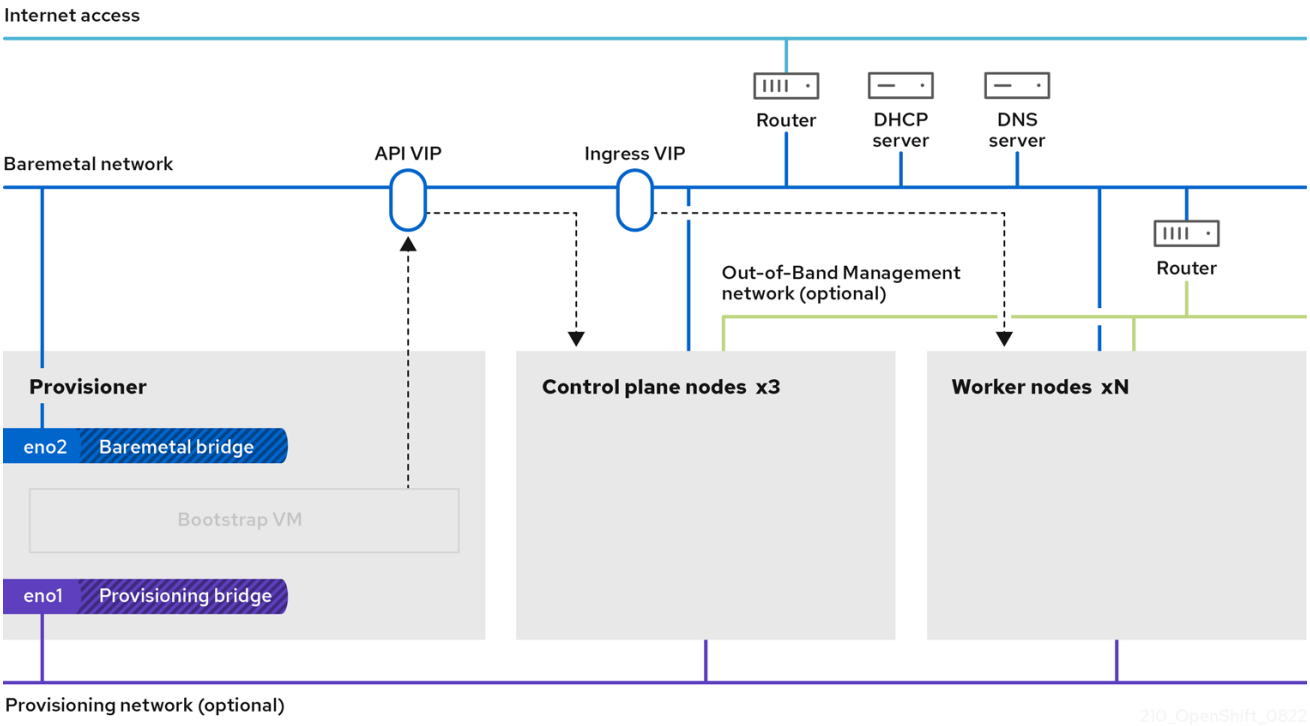
In phase 2 of the deployment, the provisioner destroys the bootstrap VM automatically and moves the virtual IP addresses (VIPs) to the appropriate nodes.

The **keepalived.conf** file sets the control plane machines with a lower Virtual Router Redundancy Protocol (VRRP) priority than the bootstrap VM, which ensures that the API on the control plane machines is fully functional before the API VIP moves from the bootstrap VM to the control plane. Once

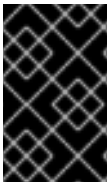
the API VIP moves to one of the control plane nodes, traffic sent from external clients to the API VIP routes to an **haproxy** load balancer running on that control plane node. This instance of **haproxy** load balances the API VIP traffic across the control plane nodes.

The Ingress VIP moves to the worker nodes. The **keepalived** instance also manages the Ingress VIP.

The following diagram illustrates phase 2 of deployment:



After this point, the node used by the provisioner can be removed or repurposed. From here, all additional provisioning tasks are carried out by the control plane.



IMPORTANT

The provisioning network is optional, but it is required for PXE booting. If you deploy without a provisioning network, you must use a virtual media baseboard management controller (BMC) addressing option such as **redfish-virtualmedia** or **idrac-virtualmedia**.

14.2. PREREQUISITES

Installer-provisioned installation of OpenShift Container Platform requires:

1. One provisioner node with Red Hat Enterprise Linux (RHEL) 8.x installed. The provisioner can be removed after installation.
2. Three control plane nodes
3. Baseboard management controller (BMC) access to each node
4. At least one network:
    a. One required routable network
    b. One optional provisioning network

c. One optional management network

Before starting an installer-provisioned installation of OpenShift Container Platform, ensure the hardware environment meets the following requirements.

14.2.1. Node requirements

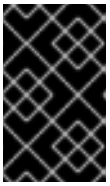
Installer-provisioned installation involves a number of hardware node requirements:

- **CPU architecture:** All nodes must use x86_64 or AArch64 CPU architecture.
- **Similar nodes:** Red Hat recommends nodes have an identical configuration per role. That is, Red Hat recommends nodes be the same brand and model with the same CPU, memory, and storage configuration.
- **Baseboard Management Controller:** The **provisioner** node must be able to access the baseboard management controller (BMC) of each OpenShift Container Platform cluster node. You may use IPMI, Redfish, or a proprietary protocol.
- **Latest generation:** Nodes must be of the most recent generation. Installer-provisioned installation relies on BMC protocols, which must be compatible across nodes. Additionally, RHEL 8 ships with the most recent drivers for RAID controllers. Ensure that the nodes are recent enough to support RHEL 8 for the **provisioner** node and RHCOS 8 for the control plane and worker nodes.
- **Registry node:** (Optional) If setting up a disconnected mirrored registry, it is recommended the registry reside in its own node.
- **Provisioner node:** Installer-provisioned installation requires one **provisioner** node.
- **Control plane:** Installer-provisioned installation requires three control plane nodes for high availability. You can deploy an OpenShift Container Platform cluster with only three control plane nodes, making the control plane nodes schedulable as worker nodes. Smaller clusters are more resource efficient for administrators and developers during development, production, and testing.
- **Worker nodes:** While not required, a typical production cluster has two or more worker nodes.

IMPORTANT

Do not deploy a cluster with only one worker node, because the cluster will deploy with routers and ingress traffic in a degraded state.

- **Network interfaces:** Each node must have at least one network interface for the routable **baremetal** network. Each node must have one network interface for a **provisioning** network when using the **provisioning** network for deployment. Using the **provisioning** network is the default configuration.
- **Unified Extensible Firmware Interface (UEFI):**Installer-provisioned installation requires UEFI boot on all OpenShift Container Platform nodes when using IPv6 addressing on the **provisioning** network. In addition, UEFI Device PXE Settings must be set to use the IPv6 protocol on the **provisioning** network NIC, but omitting the **provisioning** network removes this requirement.



IMPORTANT

When starting the installation from virtual media such as an ISO image, delete all old UEFI boot table entries. If the boot table includes entries that are not generic entries provided by the firmware, the installation might fail.

- **Secure Boot:** Many production scenarios require nodes with Secure Boot enabled to verify the node only boots with trusted software, such as UEFI firmware drivers, EFI applications, and the operating system. You may deploy with Secure Boot manually or managed.

  1. **Manually:** To deploy an OpenShift Container Platform cluster with Secure Boot manually, you must enable UEFI boot mode and Secure Boot on each control plane node and each worker node. Red Hat supports Secure Boot with manually enabled UEFI and Secure Boot only when installer-provisioned installations use Redfish virtual media. See "Configuring nodes for Secure Boot manually" in the "Configuring nodes" section for additional details.

  2. **Managed:** To deploy an OpenShift Container Platform cluster with managed Secure Boot, you must set the **bootMode** value to **UEFISecureBoot** in the **install-config.yaml** file. Red Hat only supports installer-provisioned installation with managed Secure Boot on 10th generation HPE hardware and 13th generation Dell hardware running firmware version **2.75.75.75** or greater. Deploying with managed Secure Boot does not require Redfish virtual media. See "Configuring managed Secure Boot" in the "Setting up the environment for an OpenShift installation" section for details.

NOTE

Red Hat does not support Secure Boot with self-generated keys.

14.2.2. Planning a bare metal cluster for OpenShift Virtualization

If you will use OpenShift Virtualization, it is important to be aware of several requirements before you install your bare metal cluster.

- If you want to use live migration features, you must have multiple worker nodes *at the time of cluster installation*. This is because live migration requires the cluster-level high availability (HA) flag to be set to true. The HA flag is set when a cluster is installed and cannot be changed afterwards. If there are fewer than two worker nodes defined when you install your cluster, the HA flag is set to false for the life of the cluster.

NOTE

You can install OpenShift Virtualization on a single-node cluster, but single-node OpenShift does not support high availability.

- Live migration requires shared storage. Storage for OpenShift Virtualization must support and use the ReadWriteMany (RWX) access mode.

- If you plan to use Single Root I/O Virtualization (SR-IOV), ensure that your network interface controllers (NICs) are supported by OpenShift Container Platform.

Additional resources

- Preparing your cluster for OpenShift Virtualization

- About Single Root I/O Virtualization (SR-IOV) hardware networks

- Connecting a virtual machine to an SR-IOV network

14.2.3. Firmware requirements for installing with virtual media

The installation program for installer-provisioned OpenShift Container Platform clusters validates the hardware and firmware compatibility with Redfish virtual media. The installation program does not begin installation on a node if the node firmware is not compatible. The following tables list the minimum firmware versions tested and verified to work for installer-provisioned OpenShift Container Platform clusters deployed by using Redfish virtual media.

NOTE

Red Hat does not test every combination of firmware, hardware, or other third-party components. For further information about third-party support, see Red Hat third-party support policy. For information about updating the firmware, see the hardware documentation for the nodes or contact the hardware vendor.

Table 14.1. Firmware compatibility for HP hardware with Redfish virtual media

Model	Management	Firmware versions
10th Generation	iLO5	2.63 or later

Table 14.2. Firmware compatibility for Dell hardware with Redfish virtual media

Model	Management	Firmware versions
15th Generation	iDRAC 9	v5.10.00.00 - v5.10.50.00 only
14th Generation	iDRAC 9	v5.10.00.00 - v5.10.50.00 only
13th Generation	iDRAC 8	v2.75.75.75 or later

NOTE

For Dell servers, ensure the OpenShift Container Platform cluster nodes have **AutoAttach** enabled through the iDRAC console. The menu path is **Configuration → Virtual Media → Attach Mode → AutoAttach** . With iDRAC 9 firmware version **04.40.00.00** and all releases up to including the **5.xx** series, the virtual console plugin defaults to eHTML5, an enhanced version of HTML5, which causes problems with the **InsertVirtualMedia** workflow. Set the plugin to use HTML5 to avoid this issue. The menu path is **Configuration → Virtual console → Plug-in Type → HTML5** .

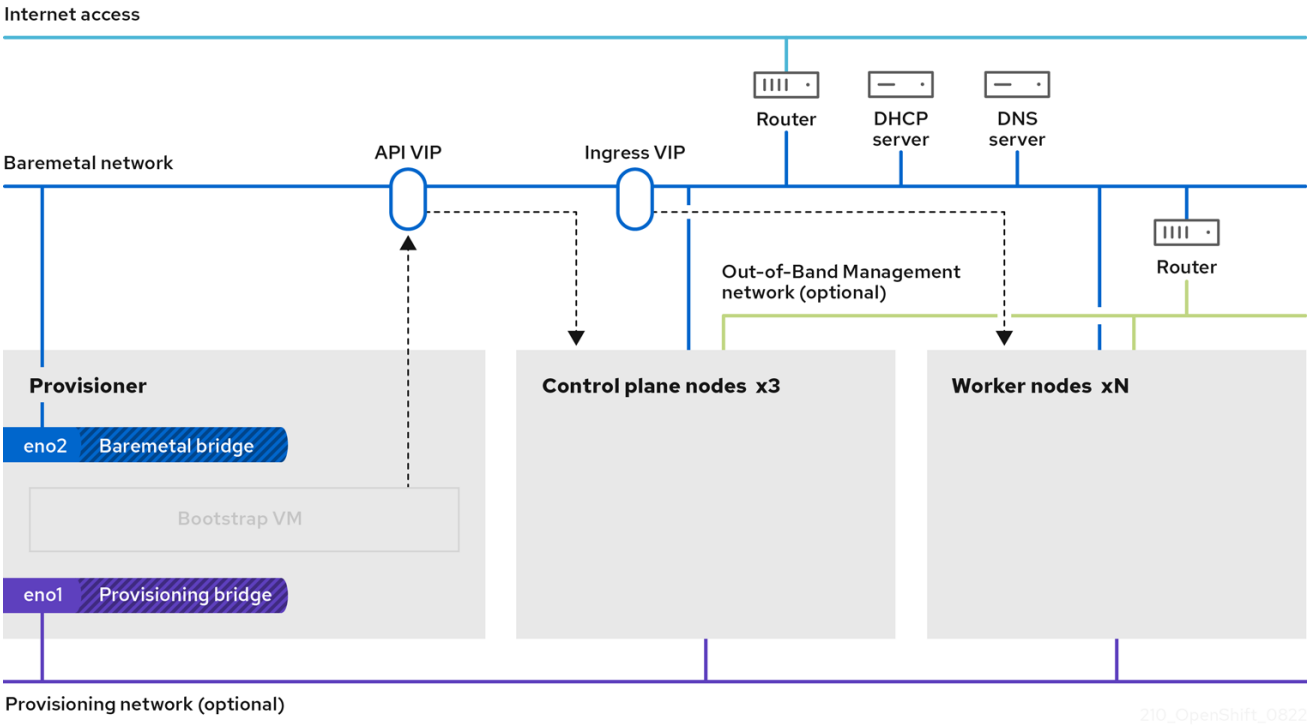
Additional resources

Unable to discover new bare metal hosts using the BMC

14.2.4. Network requirements

Installer-provisioned installation of OpenShift Container Platform involves several network requirements. First, installer-provisioned installation involves an optional non-routable **provisioning**

network for provisioning the operating system on each bare metal node. Second, installer-provisioned installation involves a routable **baremetal** network.



14.2.4.1. Increase the network MTU

Before deploying OpenShift Container Platform, increase the network maximum transmission unit (MTU) to 1500 or more. If the MTU is lower than 1500, the Ironic image that is used to boot the node might fail to communicate with the Ironic inspector pod, and inspection will fail. If this occurs, installation stops because the nodes are not available for installation.

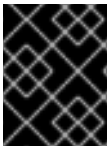
14.2.4.2. Configuring NICs

OpenShift Container Platform deploys with two networks:

- **provisioning**: The **provisioning** network is an optional non-routable network used for provisioning the underlying operating system on each node that is a part of the OpenShift Container Platform cluster. The network interface for the **provisioning** network on each cluster node must have the BIOS or UEFI configured to PXE boot.
  The **provisioningNetworkInterface** configuration setting specifies the **provisioning** network NIC name on the control plane nodes, which must be identical on the control plane nodes. The **bootMACAddress** configuration setting provides a means to specify a particular NIC on each node for the **provisioning** network.

  The **provisioning** network is optional, but it is required for PXE booting. If you deploy without a **provisioning** network, you must use a virtual media BMC addressing option such as **redfish-virtualmedia** or **idrac-virtualmedia**.

- **baremetal**: The **baremetal** network is a routable network. You can use any NIC to interface with the **baremetal** network provided the NIC is not configured to use the **provisioning** network.



IMPORTANT

When using a VLAN, each NIC must be on a separate VLAN corresponding to the appropriate network.

14.2.4.3. DNS requirements

Clients access the OpenShift Container Platform cluster nodes over the **baremetal** network. A network administrator must configure a subdomain or subzone where the canonical name extension is the cluster name.

```
<cluster_name>.<base_domain>
```

For example:

```
test-cluster.example.com
```

OpenShift Container Platform includes functionality that uses cluster membership information to generate A/AAAA records. This resolves the node names to their IP addresses. After the nodes are registered with the API, the cluster can disperse node information without using CoreDNS-mDNS. This eliminates the network traffic associated with multicast DNS.

In OpenShift Container Platform deployments, DNS name resolution is required for the following components:

- The Kubernetes API
- The OpenShift Container Platform application wildcard ingress API

A/AAAA records are used for name resolution and PTR records are used for reverse name resolution. Red Hat Enterprise Linux CoreOS (RHCOS) uses the reverse records or DHCP to set the hostnames for all the nodes.

Installer-provisioned installation includes functionality that uses cluster membership information to generate A/AAAA records. This resolves the node names to their IP addresses. In each record, **<cluster_name>** is the cluster name and **<base_domain>** is the base domain that you specify in the **install-config.yaml** file. A complete DNS record takes the form: **<component>.<cluster_name>.<base_domain>.**.

Table 14.3. Required DNS records

Component	Record	Description
Kubernetes API	**api.<cluster_name>.<base_domain>.**	An A/AAAA record and a PTR record identify the API load balancer. These records must be resolvable by both clients external to the cluster and from all the nodes within the cluster.

Component	Record	Description
Routes	***.apps.<cluster_name>.<base_domain>.**	The wildcard A/AAAA record refers to the application ingress load balancer. The application ingress load balancer targets the nodes that run the Ingress Controller pods. The Ingress Controller pods run on the worker nodes by default. These records must be resolvable by both clients external to the cluster and from all the nodes within the cluster. For example, **console-openshift-console.apps.<cluster_name>.<base_domain>** is used as a wildcard route to the OpenShift Container Platform console.

TIP

You can use the **dig** command to verify DNS resolution.

14.2.4.4. Dynamic Host Configuration Protocol (DHCP) requirements

By default, installer-provisioned installation deploys **ironic-dnsmasq** with DHCP enabled for the **provisioning** network. No other DHCP servers should be running on the **provisioning** network when the **provisioningNetwork** configuration setting is set to **managed**, which is the default value. If you have a DHCP server running on the **provisioning** network, you must set the **provisioningNetwork** configuration setting to **unmanaged** in the **install-config.yaml** file.

Network administrators must reserve IP addresses for each node in the OpenShift Container Platform cluster for the **baremetal** network on an external DHCP server.

14.2.4.5. Reserving IP addresses for nodes with the DHCP server

For the **baremetal** network, a network administrator must reserve a number of IP addresses, including:

1. Two unique virtual IP addresses.
   - One virtual IP address for the API endpoint.
   - One virtual IP address for the wildcard ingress endpoint.
2. One IP address for the provisioner node.
3. One IP address for each control plane node.
4. One IP address for each worker node, if applicable.

RESERVING IP ADDRESSES SO THEY BECOME STATIC IP ADDRESSES

Some administrators prefer to use static IP addresses so that each node's IP address remains constant in the absence of a DHCP server. To configure static IP addresses with NMState, see "(Optional) Configuring host network interfaces" in the "Setting up the environment for an OpenShift installation" section.

NETWORKING BETWEEN EXTERNAL LOAD BALANCERS AND CONTROL PLANE NODES

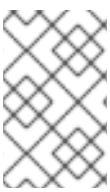
External load balancing services and the control plane nodes must run on the same L2 network, and on the same VLAN when using VLANs to route traffic between the load balancing services and the control plane nodes.

IMPORTANT

The storage interface requires a DHCP reservation or a static IP.

The following table provides an exemplary embodiment of fully qualified domain names. The API and Nameserver addresses begin with canonical name extensions. The hostnames of the control plane and worker nodes are exemplary, so you can use any host naming convention you prefer.

Usage	Host Name	IP
API	**api.<cluster_name>.<base_domain>**	**<ip>**
Ingress LB (apps)	***.apps.<cluster_name>.<base_domain>**	**<ip>**
Provisioner node	**provisioner.<cluster_name>.<base_domain>**	**<ip>**
Control-plane-0	**openshift-control-plane-0.<cluster_name>.<base_domain>**	**<ip>**
Control-plane-1	**openshift-control-plane-1.<cluster_name>-.<base_domain>**	**<ip>**
Control-plane-2	**openshift-control-plane-2.<cluster_name>.<base_domain>**	**<ip>**
Worker-0	**openshift-worker-0.<cluster_name>.<base_domain>**	**<ip>**
Worker-1	**openshift-worker-1.<cluster_name>.<base_domain>**	**<ip>**
Worker-n	**openshift-worker-n.<cluster_name>.<base_domain>**	**<ip>**



NOTE

If you do not create DHCP reservations, the installer requires reverse DNS resolution to set the hostnames for the Kubernetes API node, the provisioner node, the control plane nodes, and the worker nodes.

14.2.4.6. Provisioner node requirements

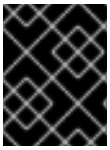
You must specify the MAC address for the provisioner node in your installation configuration. The

bootMacAddress specification is typically associated with PXE network booting. However, the Ironic provisioning service also requires the **bootMacAddress** specification to identify nodes during the inspection of the cluster, or during node redeployment in the cluster.

The provisioner node requires layer 2 connectivity for network booting, DHCP and DNS resolution, and local network communication. The provisioner node requires layer 3 connectivity for virtual media booting.

14.2.4.7. Network Time Protocol (NTP)

Each OpenShift Container Platform node in the cluster must have access to an NTP server. OpenShift Container Platform nodes use NTP to synchronize their clocks. For example, cluster nodes use SSL certificates that require validation, which might fail if the date and time between the nodes are not in sync.



IMPORTANT

Define a consistent clock date and time format in each cluster node's BIOS settings, or installation might fail.

You can reconfigure the control plane nodes to act as NTP servers on disconnected clusters, and reconfigure worker nodes to retrieve time from the control plane nodes.

14.2.4.8. Port access for the out-of-band management IP address

The out-of-band management IP address is on a separate network from the node. To ensure that the out-of-band management can communicate with the provisioner during installation, the out-of-band management IP address must be granted access to port **80** on the bootstrap host and port **6180** on the OpenShift Container Platform control plane hosts. TLS port **6183** is required for virtual media installation, for example, via Redfish.

14.2.5. Configuring nodes

Configuring nodes when using the provisioning network
Each node in the cluster requires the following configuration for proper installation.

WARNING

A mismatch between nodes will cause an installation failure.

While the cluster nodes can contain more than two NICs, the installation process only focuses on the first two NICs. In the following table, NIC1 is a non-routable network (**provisioning**) that is only used for the installation of the OpenShift Container Platform cluster.

NIC	Network	VLAN
NIC1	**provisioning**	**<provisioning_vlan>**

NIC	Network	VLAN
NIC2	**baremetal**	**<baremetal_vlan>**

The Red Hat Enterprise Linux (RHEL) 8.x installation process on the provisioner node might vary. To install Red Hat Enterprise Linux (RHEL) 8.x using a local Satellite server or a PXE server, PXE-enable NIC2.

PXE	Boot order
NIC1 PXE-enabled **provisioning** network	1
NIC2 **baremetal** network. PXE-enabled is optional.	2

NOTE

Ensure PXE is disabled on all other NICs.

Configure the control plane and worker nodes as follows:

PXE	Boot order
NIC1 PXE-enabled (provisioning network)	1

Configuring nodes without the provisioning network
The installation process requires one NIC:

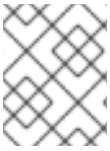
NIC	Network	VLAN
NICx	**baremetal**	**<baremetal_vlan>**

NICx is a routable network (**baremetal**) that is used for the installation of the OpenShift Container Platform cluster, and routable to the internet.

IMPORTANT

The **provisioning** network is optional, but it is required for PXE booting. If you deploy without a **provisioning** network, you must use a virtual media BMC addressing option such as **redfish-virtualmedia** or **idrac-virtualmedia**.

Configuring nodes for Secure Boot manually
Secure Boot prevents a node from booting unless it verifies the node is using only trusted software, such as UEFI firmware drivers, EFI applications, and the operating system.



NOTE

Red Hat only supports manually configured Secure Boot when deploying with Redfish virtual media.

To enable Secure Boot manually, refer to the hardware guide for the node and execute the following:

Procedure

1. Boot the node and enter the BIOS menu.
2. Set the node's boot mode to **UEFI Enabled**.
3. Enable Secure Boot.

IMPORTANT

Red Hat does not support Secure Boot with self-generated keys.

Configuring the Compatibility Support Module for Fujitsu iRMC

The Compatibility Support Module (CSM) configuration provides support for legacy BIOS backward compatibility with UEFI systems. You must configure the CSM when you deploy a cluster with Fujitsu iRMC, otherwise the installation might fail.

NOTE

For information about configuring the CSM for your specific node type, refer to the hardware guide for the node.

Prerequisites

- Ensure that you have disabled Secure Boot Control. You can disable the feature under **Security → Secure Boot Configuration → Secure Boot Control**

Procedure

1. Boot the node and select the BIOS menu.
2. Under the **Advanced** tab, select **CSM Configuration** from the list.
3. Enable the **Launch CSM** option and set the following values:

Item	Value
Boot option filter	UEFI and Legacy
Launch PXE OpROM Policy	UEFI only
Launch Storage OpROM policy	UEFI only
Other PCI device ROM priority	UEFI only

14.2.6. Out-of-band management

Nodes typically have an additional NIC used by the baseboard management controllers (BMCs). These BMCs must be accessible from the provisioner node.

Each node must be accessible via out-of-band management. When using an out-of-band management network, the provisioner node requires access to the out-of-band management network for a successful OpenShift Container Platform installation.

The out-of-band management setup is out of scope for this document. Using a separate management network for out-of-band management can enhance performance and improve security. However, using the provisioning network or the bare metal network are valid options.

NOTE

The bootstrap VM features a maximum of two network interfaces. If you configure a separate management network for out-of-band management, and you are using a provisioning network, the bootstrap VM requires routing access to the management network through one of the network interfaces. In this scenario, the bootstrap VM can then access three networks:

- the bare metal network
- the provisioning network
- the management network routed through one of the network interfaces

14.2.7. Required data for installation

Prior to the installation of the OpenShift Container Platform cluster, gather the following information from all cluster nodes:

- Out-of-band management IP
  - Examples
    - Dell (iDRAC) IP
    - HP (iLO) IP
    - Fujitsu (iRMC) IP

When using the `provisioning` network

- NIC (**`provisioning`**) MAC address
- NIC (**`baremetal`**) MAC address

When omitting the `provisioning` network

- NIC (**`baremetal`**) MAC address

14.2.8. Validation checklist for nodes

When using the `provisioning` network

❑ NIC1 VLAN is configured for the **provisioning** network.

❑ NIC1 for the **provisioning** network is PXE-enabled on the provisioner, control plane, and worker nodes.

❑ NIC2 VLAN is configured for the **baremetal** network.

❑ PXE has been disabled on all other NICs.

❑ DNS is configured with API and Ingress endpoints.

❑ Control plane and worker nodes are configured.

❑ All nodes accessible via out-of-band management.

❑ (Optional) A separate management network has been created.

❑ Required data for installation.

When omitting the provisioning network

❑ NIC1 VLAN is configured for the **baremetal** network.

❑ DNS is configured with API and Ingress endpoints.

❑ Control plane and worker nodes are configured.

❑ All nodes accessible via out-of-band management.

❑ (Optional) A separate management network has been created.

❑ Required data for installation.

14.3. SETTING UP THE ENVIRONMENT FOR AN OPENSHIFT INSTALLATION

14.3.1. Installing RHEL on the provisioner node

With the configuration of the prerequisites complete, the next step is to install RHEL 8.x on the provisioner node. The installer uses the provisioner node as the orchestrator while installing the OpenShift Container Platform cluster. For the purposes of this document, installing RHEL on the provisioner node is out of scope. However, options include but are not limited to using a RHEL Satellite server, PXE, or installation media.

14.3.2. Preparing the provisioner node for OpenShift Container Platform installation

Perform the following steps to prepare the environment.

Procedure

1. Log in to the provisioner node via **ssh**.
2. Create a non-root user (**kni**) and provide that user with **sudo** privileges:

```
# useradd kni
```

```
# passwd kni
```

```
# echo "kni ALL=(root) NOPASSWD:ALL" | tee -a /etc/sudoers.d/kni
```

```
# chmod 0440 /etc/sudoers.d/kni
```

3. Create an **ssh** key for the new user:

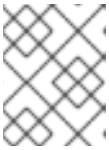
```
# su - kni -c "ssh-keygen -t ed25519 -f /home/kni/.ssh/id_rsa -N ""
```

4. Log in as the new user on the provisioner node:

```
# su - kni
```

5. Use Red Hat Subscription Manager to register the provisioner node:

```
$ sudo subscription-manager register --username=<user> --password=<pass> --auto-attach
$ sudo subscription-manager repos --enable=rhel-8-for-<architecture>-appstream-rpms --
enable=rhel-8-for-<architecture>-baseos-rpms
```



NOTE

For more information about Red Hat Subscription Manager, see Using and Configuring Red Hat Subscription Manager.

6. Install the following packages:

```
$ sudo dnf install -y libvirt qemu-kvm mkisofs python3-devel jq ipmitool
```

7. Modify the user to add the **libvirt** group to the newly created user:

```
$ sudo usermod --append --groups libvirt <user>
```

8. Restart **firewalld** and enable the **http** service:

```
$ sudo systemctl start firewalld
```

```
$ sudo firewall-cmd --zone=public --add-service=http --permanent
```

```
$ sudo firewall-cmd --reload
```

9. Start and enable the **libvirtd** service:

```
$ sudo systemctl enable libvirtd --now
```

10. Create the **default** storage pool and start it:

```
$ sudo virsh pool-define-as --name default --type dir --target /var/lib/libvirt/images
```

```
$ sudo virsh pool-start default
```

```
$ sudo virsh pool-autostart default
```

11. Create a **pull-secret.txt** file:

```
$ vim pull-secret.txt
```

In a web browser, navigate to Install OpenShift on Bare Metal with installer-provisioned infrastructure. Click **Copy pull secret**. Paste the contents into the **pull-secret.txt** file and save the contents in the **kni** user's home directory.

14.3.3. Checking NTP server synchronization

The OpenShift Container Platform installation program installs the **chrony** Network Time Protocol (NTP) service on the cluster nodes. To complete installation, each node must have access to an NTP time server. You can verify NTP server synchronization by using the **chrony** service.

For disconnected clusters, you must configure the NTP servers on the control plane nodes. For more information see the *Additional resources* section.

Prerequisites

- You installed the **chrony** package on the target node.

Procedure

1. Log in to the node by using the **ssh** command.
2. View the NTP servers available to the node by running the following command:

```
$ chronyc sources
```

Example output

```
MS Name/IP address         Stratum Poll Reach LastRx Last sample
===============================================================================
^+ time.cloudflare.com           3  10   377   187   -209us[ -209us] +/-   32ms
^+ t1.time.ir2.yahoo.com         2  10   377   185  -4382us[-4382us] +/-   23ms
^+ time.cloudflare.com           3  10   377   198   -996us[-1220us] +/-   33ms
^* brenbox.westnet.ie            1  10   377   193  -9538us[-9761us] +/-   24ms
```

3. Use the **ping** command to ensure that the node can access an NTP server, for example:

```
$ ping time.cloudflare.com
```

Example output

```
PING time.cloudflare.com (162.159.200.123) 56(84) bytes of data.
64 bytes from time.cloudflare.com (162.159.200.123): icmp_seq=1 ttl=54 time=32.3 ms
64 bytes from time.cloudflare.com (162.159.200.123): icmp_seq=2 ttl=54 time=30.9 ms
```

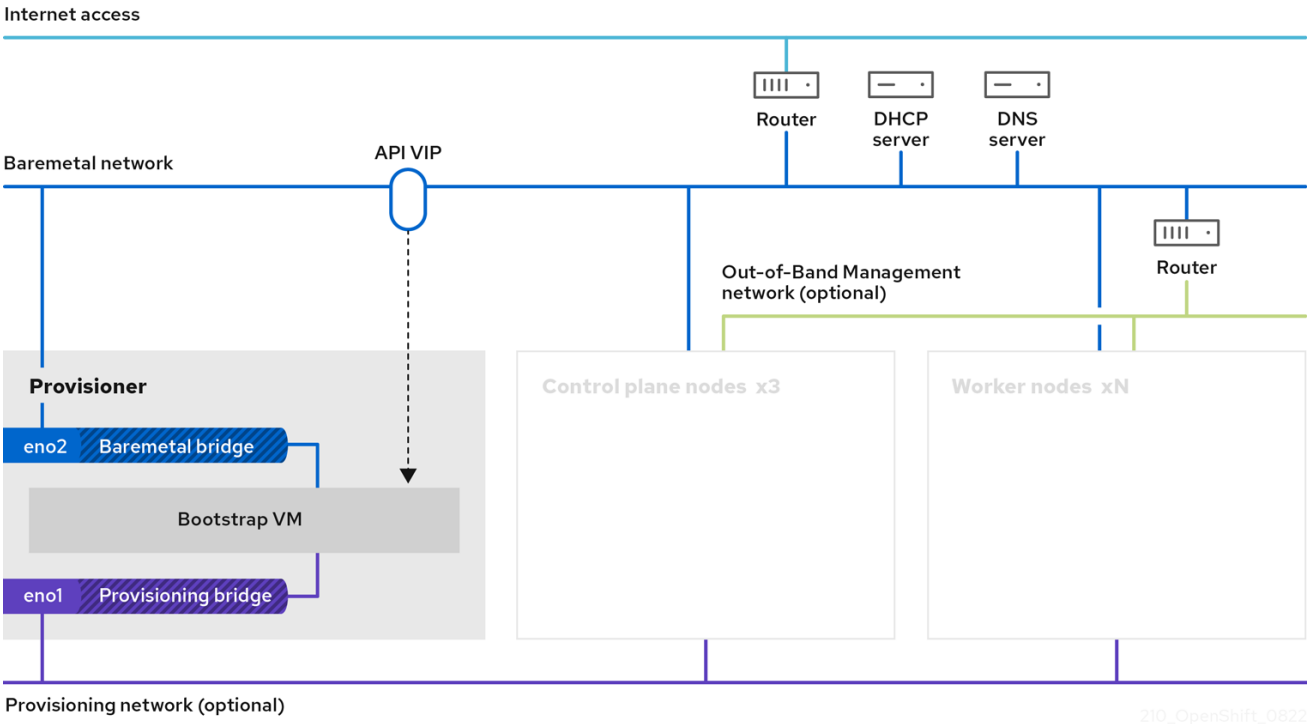
```
64 bytes from time.cloudflare.com (162.159.200.123): icmp_seq=3 ttl=54 time=36.7 ms
...
```

Additional resources

- Optional: Configuring NTP for disconnected clusters
- Network Time Protocol (NTP)

14.3.4. Configuring networking

Before installation, you must configure the networking on the provisioner node. Installer-provisioned clusters deploy with a bare-metal bridge and network, and an optional provisioning bridge and network.



NOTE

You can also configure networking from the web console.

Procedure

1. Export the bare-metal network NIC name:

```
$ export PUB_CONN=<baremetal_nic_name>
```

2. Configure the bare-metal network:

NOTE

The SSH connection might disconnect after executing these steps.

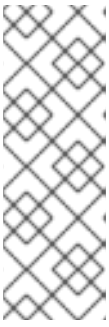
```
$ sudo nohup bash -c "
    nmcli con down \"$PUB_CONN\"
    nmcli con delete \"$PUB_CONN\"
    # RHEL 8.1 appends the word \"System\" in front of the connection, delete in case it exists
    nmcli con down \"System $PUB_CONN\"
    nmcli con delete \"System $PUB_CONN\"
    nmcli connection add ifname baremetal type bridge con-name baremetal bridge.stp no
    nmcli con add type bridge-slave ifname \"$PUB_CONN\" master baremetal
    pkill dhclient;dhclient baremetal
"
```

3. Optional: If you are deploying with a provisioning network, export the provisioning network NIC name:

```
$ export PROV_CONN=<prov_nic_name>
```

4. Optional: If you are deploying with a provisioning network, configure the provisioning network:

```
$ sudo nohup bash -c "
    nmcli con down \"$PROV_CONN\"
    nmcli con delete \"$PROV_CONN\"
    nmcli connection add ifname provisioning type bridge con-name provisioning
    nmcli con add type bridge-slave ifname \"$PROV_CONN\" master provisioning
    nmcli connection modify provisioning ipv6.addresses fd00:1101::1/64 ipv6.method manual
    nmcli con down provisioning
    nmcli con up provisioning
"
```



NOTE

The ssh connection might disconnect after executing these steps.

The IPv6 address can be any address as long as it is not routable via the bare-metal network.

Ensure that UEFI is enabled and UEFI PXE settings are set to the IPv6 protocol when using IPv6 addressing.

5. Optional: If you are deploying with a provisioning network, configure the IPv4 address on the provisioning network connection:

```
$ nmcli connection modify provisioning ipv4.addresses 172.22.0.254/24 ipv4.method manual
```

6. **ssh** back into the **provisioner** node (if required):

```
# ssh kni@provisioner.<cluster-name>.<domain>
```

7. Verify the connection bridges have been properly created:

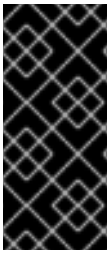
```
$ sudo nmcli con show
```

```
NAME            UUID                    TYPE      DEVICE
```

```
baremetal          4d5133a5-8351-4bb9-bfd4-3af264801530  bridge    baremetal
provisioning       43942805-017f-4d7d-a2c2-7cb3324482ed  bridge    provisioning
virbr0             d9bca40f-eee1-410b-8879-a2d4bb0465e7  bridge    virbr0
bridge-slave-eno1  76a8ed50-c7e5-4999-b4f6-6d9014dd0812  ethernet  eno1
bridge-slave-eno2  f31c3353-54b7-48de-893a-02d2b34c4736  ethernet  eno2
```

14.3.5. Establishing communication between subnets

In a typical OpenShift Container Platform cluster setup, all nodes, including the control plane and worker nodes, reside in the same network. However, for edge computing scenarios, it can be beneficial to locate worker nodes closer to the edge. This often involves using different network segments or subnets for the remote worker nodes than the subnet used by the control plane and local worker nodes. Such a setup can reduce latency for the edge and allow for enhanced scalability. However, the network must be configured properly before installing OpenShift Container Platform to ensure that the edge subnets containing the remote worker nodes can reach the subnet containing the control plane nodes and receive traffic from the control plane too.



IMPORTANT

All control plane nodes must run in the same subnet. When using more than one subnet, you can also configure the Ingress VIP to run on the control plane nodes by using a manifest. See "Configuring network components to run on the control plane" for details.

Deploying a cluster with multiple subnets requires using virtual media.

This procedure details the network configuration required to allow the remote worker nodes in the second subnet to communicate effectively with the control plane nodes in the first subnet and to allow the control plane nodes in the first subnet to communicate effectively with the remote worker nodes in the second subnet.

In this procedure, the cluster spans two subnets:

- The first subnet (**10.0.0.0**) contains the control plane and local worker nodes.
- The second subnet (**192.168.0.0**) contains the edge worker nodes.

Procedure

1. Configure the first subnet to communicate with the second subnet:
   a. Log in as **root** to a control plane node by running the following command:

      ```
      $ sudo su -
      ```

   b. Get the name of the network interface:

      ```
      # nmcli dev status
      ```

   c. Add a route to the second subnet (**192.168.0.0**) via the gateway: s+

```
# nmcli connection modify <interface_name> +ipv4.routes "192.168.0.0/24 via <gateway>"
```

+ Replace **<interface_name>** with the interface name. Replace **<gateway>** with the IP address of the actual gateway.

+ .Example

+

```
# nmcli connection modify eth0 +ipv4.routes "192.168.0.0/24 via 192.168.0.1"
```

a. Apply the changes:

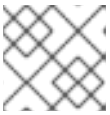
```
# nmcli connection up <interface_name>
```

Replace **<interface_name>** with the interface name.

b. Verify the routing table to ensure the route has been added successfully:

```
# ip route
```

c. Repeat the previous steps for each control plane node in the first subnet.



NOTE

Adjust the commands to match your actual interface names and gateway.

1. Configure the second subnet to communicate with the first subnet:

d. Log in as **root** to a remote worker node:

```
$ sudo su -
```

e. Get the name of the network interface:

```
# nmcli dev status
```

f. Add a route to the first subnet (**10.0.0.0**) via the gateway:

```
# nmcli connection modify <interface_name> +ipv4.routes "10.0.0.0/24 via <gateway>"
```

Replace **<interface_name>** with the interface name. Replace **<gateway>** with the IP address of the actual gateway.

Example

```
# nmcli connection modify eth0 +ipv4.routes "10.0.0.0/24 via 10.0.0.1"
```

g. Apply the changes:

```
# nmcli connection up <interface_name>
```

Replace **<interface_name>** with the interface name.

h. Verify the routing table to ensure the route has been added successfully:

```
# ip route
```

i. Repeat the previous steps for each worker node in the second subnet.

NOTE

Adjust the commands to match your actual interface names and gateway.

1. Once you have configured the networks, test the connectivity to ensure the remote worker nodes can reach the control plane nodes and the control plane nodes can reach the remote worker nodes.

j. From the control plane nodes in the first subnet, ping a remote worker node in the second subnet:

```
$ ping <remote_worker_node_ip_address>
```

If the ping is successful, it means the control plane nodes in the first subnet can reach the remote worker nodes in the second subnet. If you don't receive a response, review the network configurations and repeat the procedure for the node.

k. From the remote worker nodes in the second subnet, ping a control plane node in the first subnet:

```
$ ping <control_plane_node_ip_address>
```

If the ping is successful, it means the remote worker nodes in the second subnet can reach the control plane in the first subnet. If you don't receive a response, review the network configurations and repeat the procedure for the node.

14.3.6. Retrieving the OpenShift Container Platform installer

Use the **stable-4.x** version of the installation program and your selected architecture to deploy the generally available stable version of OpenShift Container Platform:

```
$ export VERSION=stable-4.11
```

```
$ export RELEASE_ARCH=<architecture>
```

```
$ export RELEASE_IMAGE=$(curl -s https://mirror.openshift.com/pub/openshift-v4/$RELEASE_ARCH/clients/ocp/$VERSION/release.txt | grep 'Pull From: quay.io' | awk -F ' ' '{print $3}')
```

14.3.7. Extracting the OpenShift Container Platform installer

After retrieving the installer, the next step is to extract it.

Procedure

1. Set the environment variables:

```
$ export cmd=openshift-baremetal-install
```

```
$ export pullsecret_file=~/pull-secret.txt
```

```
$ export extract_dir=$(pwd)
```

2. Get the **oc** binary:

```
$ curl -s https://mirror.openshift.com/pub/openshift-v4/clients/ocp/$VERSION/openshift-client-linux.tar.gz | tar zxvf - oc
```

3. Extract the installer:

```
$ sudo cp oc /usr/local/bin
```

```
$ oc adm release extract --registry-config "${pullsecret_file}" --command=$cmd --to "${extract_dir}" ${RELEASE_IMAGE}
```

```
$ sudo cp openshift-baremetal-install /usr/local/bin
```

14.3.8. Optional: Creating an RHCOS images cache

To employ image caching, you must download the Red Hat Enterprise Linux CoreOS (RHCOS) image used by the bootstrap VM to provision the cluster nodes. Image caching is optional, but it is especially useful when running the installation program on a network with limited bandwidth.

NOTE

The installation program no longer needs the **clusterOSImage** RHCOS image because the correct image is in the release payload.

If you are running the installation program on a network with limited bandwidth and the RHCOS images download takes more than 15 to 20 minutes, the installation program will timeout. Caching images on a web server will help in such scenarios.

WARNING

If you enable TLS for the HTTPD server, you must confirm the root certificate is signed by an authority trusted by the client and verify the trusted certificate chain between your OpenShift Container Platform hub and spoke clusters and the HTTPD server. Using a server configured with an untrusted certificate prevents the images from being downloaded to the image creation service. Using untrusted HTTPS servers is not supported.

Install a container that contains the images.

Procedure

1. Install **podman**:

```
$ sudo dnf install -y podman
```

2. Open firewall port **8080** to be used for RHCOS image caching:

```
$ sudo firewall-cmd --add-port=8080/tcp --zone=public --permanent
```

```
$ sudo firewall-cmd --reload
```

3. Create a directory to store the **bootstraposimage**:

```
$ mkdir /home/kni/rhcos_image_cache
```

4. Set the appropriate SELinux context for the newly created directory:

```
$ sudo semanage fcontext -a -t httpd_sys_content_t "/home/kni/rhcos_image_cache(/.*)?"
```

```
$ sudo restorecon -Rv /home/kni/rhcos_image_cache/
```

5. Get the URI for the RHCOS image that the installation program will deploy on the bootstrap VM:

```
$ export RHCOS_QEMU_URI=$(/usr/local/bin/openshift-baremetal-install coreos print-
stream-json | jq -r --arg ARCH "$(arch)"
'.architectures[$ARCH].artifacts.qemu.formats["qcow2.gz"].disk.location')
```

6. Get the name of the image that the installation program will deploy on the bootstrap VM:

```
$ export RHCOS_QEMU_NAME=${RHCOS_QEMU_URI##*/}
```

7. Get the SHA hash for the RHCOS image that will be deployed on the bootstrap VM:

```
$ export RHCOS_QEMU_UNCOMPRESSED_SHA256=$(/usr/local/bin/openshift-baremetal-
install coreos print-stream-json | jq -r --arg ARCH "$(arch)"
'.architectures[$ARCH].artifacts.qemu.formats["qcow2.gz"].disk["uncompressed-sha256"]')
```

8. Download the image and place it in the **/home/kni/rhcos_image_cache** directory:

```
$ curl -L ${RHCOS_QEMU_URI} -o
/home/kni/rhcos_image_cache/${RHCOS_QEMU_NAME}
```

9. Confirm SELinux type is of **httpd_sys_content_t** for the new file:

```
$ ls -Z /home/kni/rhcos_image_cache
```

10. Create the pod:

```
$ podman run -d --name rhcos_image_cache \ 1
-v /home/kni/rhcos_image_cache:/var/www/html \
-p 8080:8080/tcp \
quay.io/centos7/httpd-24-centos7:latest
```

1 Creates a caching webserver with the name **rhcos_image_cache**. This pod serves the **bootstrapOSImage** image in the **install-config.yaml** file for deployment.

11. Generate the **bootstrapOSImage** configuration:

```
$ export BAREMETAL_IP=$(ip addr show dev baremetal | awk '/inet /{print $2}' | cut -d"/" -f1)
```

```
$ export
BOOTSTRAP_OS_IMAGE="http://${BAREMETAL_IP}:8080/${RHCOS_QEMU_NAME}?
sha256=${RHCOS_QEMU_UNCOMPRESSED_SHA256}"
```

```
$ echo "    bootstrapOSImage=${BOOTSTRAP_OS_IMAGE}"
```

12. Add the required configuration to the **install-config.yaml** file under **platform.baremetal**:

```
platform:
  baremetal:
    bootstrapOSImage: <bootstrap_os_image> 1
```

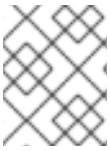
1 Replace **<bootstrap_os_image>** with the value of **$BOOTSTRAP_OS_IMAGE**.

See the "Configuring the install-config.yaml file" section for additional details.

14.3.9. Configuring the install-config.yaml file

14.3.9.1. Configuring the install-config.yaml file

The **install-config.yaml** file requires some additional details. Most of the information teaches the installation program and the resulting cluster enough about the available hardware that it is able to fully manage it.



NOTE

The installation program no longer needs the **clusterOSImage** RHCOS image because the correct image is in the release payload.

1. Configure **install-config.yaml**. Change the appropriate variables to match the environment, including **pullSecret** and **sshKey**:

```
apiVersion: v1
baseDomain: <domain>
metadata:
  name: <cluster_name>
networking:
  machineNetwork:
  - cidr: <public_cidr>
  networkType: OVNKubernetes
compute:
- name: worker
  replicas: 2 1
controlPlane:
```

```
  name: master
  replicas: 3
  platform:
    baremetal: {}
platform:
  baremetal:
    apiVIP: <api_ip>
    ingressVIP: <wildcard_ip>
    provisioningNetworkCIDR: <CIDR>
    bootstrapExternalStaticIP: <bootstrap_static_ip_address> 2
    bootstrapExternalStaticGateway: <bootstrap_static_gateway> 3
    hosts:
      - name: openshift-master-0
        role: master
        bmc:
          address: ipmi://<out_of_band_ip> 4
          username: <user>
          password: <password>
        bootMACAddress: <NIC1_mac_address>
        rootDeviceHints:
         deviceName: "<installation_disk_drive_path>" 5
      - name: <openshift_master_1>
        role: master
        bmc:
          address: ipmi://<out_of_band_ip>
          username: <user>
          password: <password>
        bootMACAddress: <NIC1_mac_address>
        rootDeviceHints:
         deviceName: "<installation_disk_drive_path>"
      - name: <openshift_master_2>
        role: master
        bmc:
          address: ipmi://<out_of_band_ip>
          username: <user>
          password: <password>
        bootMACAddress: <NIC1_mac_address>
        rootDeviceHints:
         deviceName: "<installation_disk_drive_path>"
      - name: <openshift_worker_0>
        role: worker
        bmc:
          address: ipmi://<out_of_band_ip>
          username: <user>
          password: <password>
        bootMACAddress: <NIC1_mac_address>
      - name: <openshift_worker_1>
        role: worker
        bmc:
          address: ipmi://<out_of_band_ip>
          username: <user>
          password: <password>
        bootMACAddress: <NIC1_mac_address>
        rootDeviceHints:
```

```
      deviceName: "<installation_disk_drive_path>"
pullSecret: '<pull_secret>'
sshKey: '<ssh_pub_key>'
```

1. Scale the worker machines based on the number of worker nodes that are part of the OpenShift Container Platform cluster. Valid options for the **replicas** value are **0** and integers greater than or equal to **2**. Set the number of replicas to **0** to deploy a three-node cluster, which contains only three control plane machines. A three-node cluster is a smaller, more resource-efficient cluster that can be used for testing, development, and production. You cannot install the cluster with only one worker.
2. When deploying a cluster with static IP addresses, you must set the **bootstrapExternalStaticIP** configuration setting to specify the static IP address of the bootstrap VM when there is no DHCP server on the bare-metal network.
3. When deploying a cluster with static IP addresses, you must set the **bootstrapExternalStaticGateway** configuration setting to specify the gateway IP address for the bootstrap VM when there is no DHCP server on the bare-metal network.
4. See the BMC addressing sections for more options.
5. To set the path to the installation disk drive, enter the kernel name of the disk. For example, **/dev/sda**.

IMPORTANT

Because the disk discovery order is not guaranteed, the kernel name of the disk can change across booting options for machines with multiple disks. For instance, **/dev/sda** becomes **/dev/sdb** and vice versa. To avoid this issue, you must use persistent disk attributes, such as the disk World Wide Name (WWN). To use the disk WWN, replace the **deviceName** parameter with the **wwnWithExtension** parameter. Depending on the parameter that you use, enter the disk name, for example, **/dev/sda** or the disk WWN, for example, **"0x64cd98f04fde100024684cf3034da5c2"**. Ensure that you enter the disk WWN value within quotes so that it is used as a string value and not a hexadecimal value.

Failure to meet these requirements for the **rootDeviceHints** parameter might result in the following error:

```
ironic-inspector inspection failed: No disks satisfied root device hints
```

2. Create a directory to store the cluster configuration:

```
$ mkdir ~/clusterconfigs
```

3. Copy the **install-config.yaml** file to the new directory:

```
$ cp install-config.yaml ~/clusterconfigs
```

4. Ensure all bare metal nodes are powered off prior to installing the OpenShift Container Platform cluster:

```
$ ipmitool -I lanplus -U <user> -P <password> -H <management-server-ip> power off
```

5. Remove old bootstrap resources if any are left over from a previous deployment attempt:

```
for i in $(sudo virsh list | tail -n +3 | grep bootstrap | awk {'print $2'});
do
  sudo virsh destroy $i;
  sudo virsh undefine $i;
  sudo virsh vol-delete $i --pool $i;
  sudo virsh vol-delete $i.ign --pool $i;
  sudo virsh pool-destroy $i;
  sudo virsh pool-undefine $i;
done
```

14.3.9.2. Additional **install-config** parameters

See the following tables for the required parameters, the **hosts** parameter, and the **bmc** parameter for the **install-config.yaml** file.

Table 14.4. Required parameters

Parameters	Default	Description
baseDomain		The domain name for the cluster. For example, **example.com**.
bootMode	**UEFI**	The boot mode for a node. Options are **legacy**, **UEFI**, and **UEFISecureBoot**. If **bootMode** is not set, Ironic sets it while inspecting the node.
bootstrapExternalStaticIP		The static IP address for the bootstrap VM. You must set this value when deploying a cluster with static IP addresses when there is no DHCP server on the bare-metal network.
bootstrapExternalStaticGateway		The static IP address of the gateway for the bootstrap VM. You must set this value when deploying a cluster with static IP addresses when there is no DHCP server on the bare-metal network.

Parameters	Default	Description
sshKey		The **sshKey** configuration setting contains the key in the **~/.ssh/id_rsa.pub** file required to access the control plane nodes and worker nodes. Typically, this key is from the **provisioner** node.
pullSecret		The **pullSecret** configuration setting contains a copy of the pull secret downloaded from the Install OpenShift on Bare Metal page when preparing the provisioner node.
`metadata:` `  name:`		The name to be given to the OpenShift Container Platform cluster. For example, **openshift**.
`networking:` `  machineNetwork:` `  - cidr:`		The public CIDR (Classless Inter-Domain Routing) of the external network. For example, **10.0.0.0/24**.
`compute:` `  - name: worker`		The OpenShift Container Platform cluster requires a name be provided for worker (or compute) nodes even if there are zero nodes.
`compute:` `  replicas: 2`		Replicas sets the number of worker (or compute) nodes in the OpenShift Container Platform cluster.
`controlPlane:` `  name: master`		The OpenShift Container Platform cluster requires a name for control plane (master) nodes.
`controlPlane:` `  replicas: 3`		Replicas sets the number of control plane (master) nodes included as part of the OpenShift Container Platform cluster.

Parameters	Default	Description
provisioningNetworkInterface		The name of the network interface on nodes connected to the provisioning network. For OpenShift Container Platform 4.9 and later releases, use the **bootMACAddress** configuration setting to enable Ironic to identify the IP address of the NIC instead of using the **provisioningNetworkInterface** configuration setting to identify the name of the NIC.
defaultMachinePlatform		The default configuration used for machine pools without a platform configuration.
apiVIP		(Optional) The virtual IP address for Kubernetes API communication. This setting must either be provided in the **install-config.yaml** file as a reserved IP from the MachineNetwork or pre-configured in the DNS so that the default name resolves correctly. Use the virtual IP address and not the FQDN when adding a value to the **apiVIP** configuration setting in the **install-config.yaml** file. The IP address must be from the primary IPv4 network when using dual stack networking. If not set, the installer uses **api.<cluster_name>.<base_domain>** to derive the IP address from the DNS.
disableCertificateVerification	**False**	**redfish** and **redfish-virtualmedia** need this parameter to manage BMC addresses. The value should be **True** when using a self-signed certificate for BMC addresses.

Parameters	Default	Description
ingressVIP		(Optional) The virtual IP address for ingress traffic. This setting must either be provided in the **install-config.yaml** file as a reserved IP from the MachineNetwork or pre-configured in the DNS so that the default name resolves correctly. Use the virtual IP address and not the FQDN when adding a value to the **ingressVIP** configuration setting in the **install-config.yaml** file. The IP address must be from the primary IPv4 network when using dual stack networking. If not set, the installer uses **test.apps.<cluster_name>.<base_domain>** to derive the IP address from the DNS.

Table 14.5. Optional Parameters

Parameters	Default	Description
provisioningDHCPRange	**172.22.0.10,172.22.0.100**	Defines the IP range for nodes on the provisioning network.
provisioningNetworkCIDR	**172.22.0.0/24**	The CIDR for the network to use for provisioning. This option is required when not using the default address range on the provisioning network.
clusterProvisioningIP	The third IP address of the **provisioningNetworkCIDR**.	The IP address within the cluster where the provisioning services run. Defaults to the third IP address of the provisioning subnet. For example, **172.22.0.3**.
bootstrapProvisioningIP	The second IP address of the **provisioningNetworkCIDR**.	The IP address on the bootstrap VM where the provisioning services run while the installer is deploying the control plane (master) nodes. Defaults to the second IP address of the provisioning subnet. For example, **172.22.0.2** or **2620:52:0:1307::2**.
externalBridge	**baremetal**	The name of the bare-metal bridge of the hypervisor attached to the bare-metal network.
provisioningBridge	**provisioning**	The name of the provisioning bridge on the **provisioner** host attached to the provisioning network.

Parameters	Default	Description
architecture		Defines the host architecture for your cluster. Valid values are **amd64** or **arm64**.
defaultMachinePlatform		The default configuration used for machine pools without a platform configuration.
bootstrapOSImage		A URL to override the default operating system image for the bootstrap node. The URL must contain a SHA-256 hash of the image. For example: **https://mirror.openshift.com/rhcos-<version>-qemu.qcow2.gz?sha256=<uncompressed_sha256>**.
provisioningNetwork		The **provisioningNetwork** configuration setting determines whether the cluster uses the provisioning network. If it does, the configuration setting also determines if the cluster manages the network. **Disabled**: Set this parameter to **Disabled** to disable the requirement for a provisioning network. When set to **Disabled**, you must only use virtual media based provisioning, or bring up the cluster using the assisted installer. If **Disabled** and using power management, BMCs must be accessible from the bare-metal network. If **Disabled**, you must provide two IP addresses on the bare-metal network that are used for the provisioning services. **Managed**: Set this parameter to **Managed**, which is the default, to fully manage the provisioning network, including DHCP, TFTP, and so on. **Unmanaged**: Set this parameter to **Unmanaged** to enable the provisioning network but take care of manual configuration of DHCP. Virtual media provisioning is recommended but PXE is still available if required.
httpProxy		Set this parameter to the appropriate HTTP proxy used within your environment.
httpsProxy		Set this parameter to the appropriate HTTPS proxy used within your environment.
noProxy		Set this parameter to the appropriate list of exclusions for proxy usage within your environment.

Hosts

The **hosts** parameter is a list of separate bare metal assets used to build the cluster.

Table 14.6. Hosts

Name	Default	Description
name		The name of the **BareMetalHost** resource to associate with the details. For example, **openshift-master-0**.
role		The role of the bare metal node. Either **master** or **worker**.
bmc		Connection details for the baseboard management controller. See the BMC addressing section for additional details.
bootMACAddress		The MAC address of the NIC that the host uses for the provisioning network. Ironic retrieves the IP address using the **bootMACAddress** configuration setting. Then, it binds to the host.  NOTE You must provide a valid MAC address from the host if you disabled the provisioning network.
networkConfig		Set this optional parameter to configure the network interface of a host. See "(Optional) Configuring host network interfaces" for additional details.

14.3.9.3. BMC addressing

Most vendors support Baseboard Management Controller (BMC) addressing with the Intelligent Platform Management Interface (IPMI). IPMI does not encrypt communications. It is suitable for use within a data center over a secured or dedicated management network. Check with your vendor to see if they support Redfish network boot. Redfish delivers simple and secure management for converged, hybrid IT and the Software Defined Data Center (SDDC). Redfish is human readable and machine capable, and leverages common internet and web services standards to expose information directly to the modern tool chain. If your hardware does not support Redfish network boot, use IPMI.

IPMI

Hosts using IPMI use the **ipmi://<out-of-band-ip>:<port>** address format, which defaults to port **623** if not specified. The following example demonstrates an IPMI configuration within the **install-config.yaml** file.

```
platform:
  baremetal:
    hosts:
      - name: openshift-master-0
        role: master
        bmc:
          address: ipmi://<out-of-band-ip>
          username: <user>
          password: <password>
```

-

IMPORTANT

The **provisioning** network is required when PXE booting using IPMI for BMC addressing. It is not possible to PXE boot hosts without a **provisioning** network. If you deploy without a **provisioning** network, you must use a virtual media BMC addressing option such as **redfish-virtualmedia** or **idrac-virtualmedia**. See "Redfish virtual media for HPE iLO" in the "BMC addressing for HPE iLO" section or "Redfish virtual media for Dell iDRAC" in the "BMC addressing for Dell iDRAC" section for additional details.

Redfish network boot
To enable Redfish, use **redfish://** or **redfish+http://** to disable TLS. The installer requires both the hostname or the IP address and the path to the system ID. The following example demonstrates a Redfish configuration within the **install-config.yaml** file.

```
platform:
  baremetal:
    hosts:
      - name: openshift-master-0
        role: master
        bmc:
          address: redfish://<out-of-band-ip>/redfish/v1/Systems/1
          username: <user>
          password: <password>
```

While it is recommended to have a certificate of authority for the out-of-band management addresses, you must include **disableCertificateVerification: True** in the **bmc** configuration if using self-signed certificates. The following example demonstrates a Redfish configuration using the **disableCertificateVerification: True** configuration parameter within the **install-config.yaml** file.

```
platform:
  baremetal:
    hosts:
      - name: openshift-master-0
        role: master
        bmc:
          address: redfish://<out-of-band-ip>/redfish/v1/Systems/1
          username: <user>
          password: <password>
          disableCertificateVerification: True
```

Redfish APIs
Several redfish API endpoints are called onto your BCM when using the bare-metal installer-provisioned infrastructure.

IMPORTANT

You need to ensure that your BMC supports all of the redfish APIs before installation.

List of redfish APIs

- Power on

```
curl -u $USER:$PASS -X POST -H'Content-Type: application/json' -H'Accept: application/json' -d '{"Action": "Reset", "ResetType": "On"}' https://$SERVER/redfish/v1/Systems/$SystemID/Actions/ComputerSystem.Reset
```

- Power off

```
curl -u $USER:$PASS -X POST -H'Content-Type: application/json' -H'Accept: application/json' -d '{"Action": "Reset", "ResetType": "ForceOff"}' https://$SERVER/redfish/v1/Systems/$SystemID/Actions/ComputerSystem.Reset
```

- Temporary boot using **pxe**

```
curl -u $USER:$PASS -X PATCH -H "Content-Type: application/json" https://$Server/redfish/v1/Systems/$SystemID/ -d '{"Boot": {"BootSourceOverrideTarget": "pxe", "BootSourceOverrideEnabled": "Once"}}
```

- Set BIOS boot mode using **Legacy** or **UEFI**

```
curl -u $USER:$PASS -X PATCH -H "Content-Type: application/json" https://$Server/redfish/v1/Systems/$SystemID/ -d '{"Boot": {"BootSourceOverrideMode":"UEFI"}}
```

List of redfish-virtualmedia APIs

- Set temporary boot device using **cd** or **dvd**

```
curl -u $USER:$PASS -X PATCH -H "Content-Type: application/json" https://$Server/redfish/v1/Systems/$SystemID/ -d '{"Boot": {"BootSourceOverrideTarget": "cd", "BootSourceOverrideEnabled": "Once"}}'
```

- Mount virtual media

```
curl -u $USER:$PASS -X PATCH -H "Content-Type: application/json" -H "If-Match: *" https://$Server/redfish/v1/Managers/$ManagerID/VirtualMedia/$VmediaId -d '{"Image": "https://example.com/test.iso", "TransferProtocolType": "HTTPS", "UserName": "", "Password":""}'
```

NOTE

The **PowerOn** and **PowerOff** commands for redfish APIs are the same for the redfish-virtualmedia APIs.

IMPORTANT

HTTPS and **HTTP** are the only supported parameter types for **TransferProtocolTypes**.

14.3.9.4. BMC addressing for Dell iDRAC

The **address** field for each **bmc** entry is a URL for connecting to the OpenShift Container Platform cluster nodes, including the type of controller in the URL scheme and its location on the network.

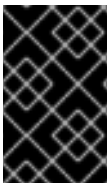
```
platform:
  baremetal:
    hosts:
      - name: <hostname>
        role: <master | worker>
        bmc:
          address: <address> 1
          username: <user>
          password: <password>
```

1 The **address** configuration setting specifies the protocol.

For Dell hardware, Red Hat supports integrated Dell Remote Access Controller (iDRAC) virtual media, Redfish network boot, and IPMI.

BMC address formats for Dell iDRAC

Protocol	Address Format
iDRAC virtual media	**idrac-virtualmedia://<out-of-band-ip>/redfish/v1/Systems/System.Embedded.1**
Redfish network boot	**redfish://<out-of-band-ip>/redfish/v1/Systems/System.Embedded.1**
IPMI	**ipmi://<out-of-band-ip>**



IMPORTANT

Use **idrac-virtualmedia** as the protocol for Redfish virtual media. **redfish-virtualmedia** will not work on Dell hardware. Dell's **idrac-virtualmedia** uses the Redfish standard with Dell's OEM extensions.

See the following sections for additional details.

Redfish virtual media for Dell iDRAC
For Redfish virtual media on Dell servers, use **idrac-virtualmedia://** in the **address** setting. Using **redfish-virtualmedia://** will not work.

The following example demonstrates using iDRAC virtual media within the **install-config.yaml** file.

```
platform:
  baremetal:
    hosts:
      - name: openshift-master-0
        role: master
        bmc:
          address: idrac-virtualmedia://<out-of-band-ip>/redfish/v1/Systems/System.Embedded.1
          username: <user>
          password: <password>
```

While it is recommended to have a certificate of authority for the out-of-band management addresses, you must include **disableCertificateVerification: True** in the **bmc** configuration if using self-signed

certificates. The following example demonstrates a Redfish configuration using the **disableCertificateVerification: True** configuration parameter within the **install-config.yaml** file.

```
platform:
  baremetal:
    hosts:
      - name: openshift-master-0
        role: master
        bmc:
          address: idrac-virtualmedia://<out-of-band-ip>/redfish/v1/Systems/System.Embedded.1
          username: <user>
          password: <password>
          disableCertificateVerification: True
```

NOTE

There is a known issue on Dell iDRAC 9 with firmware version **04.40.00.00** or later for installer-provisioned installations on bare metal deployments. The Virtual Console plugin defaults to eHTML5, an enhanced version of HTML5, which causes problems with the **InsertVirtualMedia** workflow. Set the plugin to use HTML5 to avoid this issue. The menu path is **Configuration → Virtual console → Plug-in Type → HTML5** .

Ensure the OpenShift Container Platform cluster nodes have **AutoAttach** enabled through the iDRAC console. The menu path is: **Configuration → Virtual Media → Attach Mode → AutoAttach** .

Use **idrac-virtualmedia://** as the protocol for Redfish virtual media. Using **redfish-virtualmedia://** will not work on Dell hardware, because the **idrac-virtualmedia://** protocol corresponds to the **idrac** hardware type and the Redfish protocol in Ironic. Dell's **idrac-virtualmedia://** protocol uses the Redfish standard with Dell's OEM extensions. Ironic also supports the **idrac** type with the WSMAN protocol. Therefore, you must specify **idrac-virtualmedia://** to avoid unexpected behavior when electing to use Redfish with virtual media on Dell hardware.

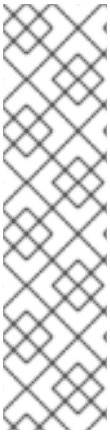
Redfish network boot for iDRAC

To enable Redfish, use **redfish://** or **redfish+http://** to disable transport layer security (TLS). The installer requires both the hostname or the IP address and the path to the system ID. The following example demonstrates a Redfish configuration within the **install-config.yaml** file.

```
platform:
  baremetal:
    hosts:
      - name: openshift-master-0
        role: master
        bmc:
          address: redfish://<out-of-band-ip>/redfish/v1/Systems/System.Embedded.1
          username: <user>
          password: <password>
```

While it is recommended to have a certificate of authority for the out-of-band management addresses, you must include **disableCertificateVerification: True** in the **bmc** configuration if using self-signed certificates. The following example demonstrates a Redfish configuration using the **disableCertificateVerification: True** configuration parameter within the **install-config.yaml** file.

```
platform:
  baremetal:
    hosts:
      - name: openshift-master-0
        role: master
        bmc:
          address: redfish://<out-of-band-ip>/redfish/v1/Systems/System.Embedded.1
          username: <user>
          password: <password>
          disableCertificateVerification: True
```



NOTE

There is a known issue on Dell iDRAC 9 with firmware version **04.40.00.00** and all releases up to including the **5.xx** series for installer-provisioned installations on bare metal deployments. The virtual console plugin defaults to eHTML5, an enhanced version of HTML5, which causes problems with the **InsertVirtualMedia** workflow. Set the plugin to use HTML5 to avoid this issue. The menu path is **Configuration → Virtual console → Plug-in Type → HTML5** .

Ensure the OpenShift Container Platform cluster nodes have **AutoAttach** enabled through the iDRAC console. The menu path is: **Configuration → Virtual Media → Attach Mode → AutoAttach** .

14.3.9.5. BMC addressing for HPE iLO

The **address** field for each **bmc** entry is a URL for connecting to the OpenShift Container Platform cluster nodes, including the type of controller in the URL scheme and its location on the network.

```
platform:
  baremetal:
    hosts:
      - name: <hostname>
        role: <master | worker>
        bmc:
          address: <address> 1
          username: <user>
          password: <password>
```

1 The **address** configuration setting specifies the protocol.

For HPE integrated Lights Out (iLO), Red Hat supports Redfish virtual media, Redfish network boot, and IPMI.

Table 14.7. BMC address formats for HPE iLO

Protocol	Address Format
Redfish virtual media	**redfish-virtualmedia://<out-of-band-ip>/redfish/v1/Systems/1**
Redfish network boot	**redfish://<out-of-band-ip>/redfish/v1/Systems/1**

Protocol	Address Format
IPMI	**ipmi://<out-of-band-ip>**

See the following sections for additional details.

Redfish virtual media for HPE iLO
To enable Redfish virtual media for HPE servers, use **redfish-virtualmedia://** in the **address** setting. The following example demonstrates using Redfish virtual media within the **install-config.yaml** file.

```
platform:
  baremetal:
    hosts:
      - name: openshift-master-0
        role: master
        bmc:
          address: redfish-virtualmedia://<out-of-band-ip>/redfish/v1/Systems/1
          username: <user>
          password: <password>
```

While it is recommended to have a certificate of authority for the out-of-band management addresses, you must include **disableCertificateVerification: True** in the **bmc** configuration if using self-signed certificates. The following example demonstrates a Redfish configuration using the **disableCertificateVerification: True** configuration parameter within the **install-config.yaml** file.

```
platform:
  baremetal:
    hosts:
      - name: openshift-master-0
        role: master
        bmc:
          address: redfish-virtualmedia://<out-of-band-ip>/redfish/v1/Systems/1
          username: <user>
          password: <password>
          disableCertificateVerification: True
```

NOTE

Redfish virtual media is not supported on 9th generation systems running iLO4, because Ironic does not support iLO4 with virtual media.

Redfish network boot for HPE iLO
To enable Redfish, use **redfish://** or **redfish+http://** to disable TLS. The installer requires both the hostname or the IP address and the path to the system ID. The following example demonstrates a Redfish configuration within the **install-config.yaml** file.

```
platform:
  baremetal:
    hosts:
      - name: openshift-master-0
        role: master
        bmc:
```

```
      address: redfish://<out-of-band-ip>/redfish/v1/Systems/1
      username: <user>
      password: <password>
```

While it is recommended to have a certificate of authority for the out-of-band management addresses, you must include **disableCertificateVerification: True** in the **bmc** configuration if using self-signed certificates. The following example demonstrates a Redfish configuration using the **disableCertificateVerification: True** configuration parameter within the **install-config.yaml** file.

```
platform:
  baremetal:
    hosts:
      - name: openshift-master-0
        role: master
        bmc:
          address: redfish://<out-of-band-ip>/redfish/v1/Systems/1
          username: <user>
          password: <password>
          disableCertificateVerification: True
```

14.3.9.6. BMC addressing for Fujitsu iRMC

The **address** field for each **bmc** entry is a URL for connecting to the OpenShift Container Platform cluster nodes, including the type of controller in the URL scheme and its location on the network.

```
platform:
  baremetal:
    hosts:
      - name: <hostname>
        role: <master | worker>
        bmc:
          address: <address> 1
          username: <user>
          password: <password>
```

1 The **address** configuration setting specifies the protocol.

For Fujitsu hardware, Red Hat supports integrated Remote Management Controller (iRMC) and IPMI.

Table 14.8. BMC address formats for Fujitsu iRMC

Protocol	Address Format
iRMC	**irmc://<out-of-band-ip>**
IPMI	**ipmi://<out-of-band-ip>**

iRMC

Fujitsu nodes can use **irmc://<out-of-band-ip>** and defaults to port **443**. The following example demonstrates an iRMC configuration within the **install-config.yaml** file.

```
platform:
  baremetal:
    hosts:
      - name: openshift-master-0
        role: master
        bmc:
          address: irmc://<out-of-band-ip>
          username: <user>
          password: <password>
```

NOTE

Currently Fujitsu supports iRMC S5 firmware version 3.05P and above for installer-provisioned installation on bare metal.

14.3.9.7. Root device hints

The **rootDeviceHints** parameter enables the installer to provision the Red Hat Enterprise Linux CoreOS (RHCOS) image to a particular device. The installer examines the devices in the order it discovers them, and compares the discovered values with the hint values. The installer uses the first discovered device that matches the hint value. The configuration can combine multiple hints, but a device must match all hints for the installer to select it.

Table 14.9. Subfields

Subfield	Description
deviceName	A string containing a Linux device name like **/dev/vda**. The hint must match the actual value exactly.
hctl	A string containing a SCSI bus address like **0:0:0:0**. The hint must match the actual value exactly.
model	A string containing a vendor-specific device identifier. The hint can be a substring of the actual value.
vendor	A string containing the name of the vendor or manufacturer of the device. The hint can be a sub-string of the actual value.
serialNumber	A string containing the device serial number. The hint must match the actual value exactly.
minSizeGigabytes	An integer representing the minimum size of the device in gigabytes.
wwn	A string containing the unique storage identifier. The hint must match the actual value exactly.

Subfield	Description
wwnWithExtension	A string containing the unique storage identifier with the vendor extension appended. The hint must match the actual value exactly.
wwnVendorExtension	A string containing the unique vendor storage identifier. The hint must match the actual value exactly.
rotational	A boolean indicating whether the device should be a rotating disk (true) or not (false).

Example usage

```
    - name: master-0
      role: master
      bmc:
        address: ipmi://10.10.0.3:6203
        username: admin
        password: redhat
      bootMACAddress: de:ad:be:ef:00:40
      rootDeviceHints:
        deviceName: "/dev/sda"
```

14.3.9.8. Optional: Setting proxy settings

To deploy an OpenShift Container Platform cluster using a proxy, make the following changes to the **install-config.yaml** file.

```
apiVersion: v1
baseDomain: <domain>
proxy:
  httpProxy: http://USERNAME:PASSWORD@proxy.example.com:PORT
  httpsProxy: https://USERNAME:PASSWORD@proxy.example.com:PORT
  noProxy: <WILDCARD_OF_DOMAIN>,<PROVISIONING_NETWORK/CIDR>,
<BMC_ADDRESS_RANGE/CIDR>
```

The following is an example of **noProxy** with values.

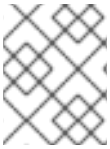
```
noProxy: .example.com,172.22.0.0/24,10.10.0.0/24
```

With a proxy enabled, set the appropriate values of the proxy in the corresponding key/value pair.

Key considerations:

- If the proxy does not have an HTTPS proxy, change the value of **httpsProxy** from **https://** to **http://**.
- If using a provisioning network, include it in the **noProxy** setting, otherwise the installer will fail.

- Set all of the proxy settings as environment variables within the provisioner node. For example, **HTTP_PROXY**, **HTTPS_PROXY**, and **NO_PROXY**.



NOTE

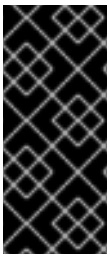
When provisioning with IPv6, you cannot define a CIDR address block in the **noProxy** settings. You must define each address separately.

14.3.9.9. Optional: Deploying with no provisioning network

To deploy an OpenShift Container Platform cluster without a **provisioning** network, make the following changes to the **install-config.yaml** file.

```
platform:
  baremetal:
    apiVIP: <api_VIP>
    ingressVIP: <ingress_VIP>
    provisioningNetwork: "Disabled" 1
```

1 Add the **provisioningNetwork** configuration setting, if needed, and set it to **Disabled**.



IMPORTANT

The **provisioning** network is required for PXE booting. If you deploy without a **provisioning** network, you must use a virtual media BMC addressing option such as **redfish-virtualmedia** or **idrac-virtualmedia**. See "Redfish virtual media for HPE iLO" in the "BMC addressing for HPE iLO" section or "Redfish virtual media for Dell iDRAC" in the "BMC addressing for Dell iDRAC" section for additional details.

14.3.9.10. Optional: Deploying with dual-stack networking

To deploy an OpenShift Container Platform cluster with dual-stack networking, edit the **machineNetwork**, **clusterNetwork**, and **serviceNetwork** configuration settings in the **install-config.yaml** file. Each setting must have two CIDR entries each. Ensure the first CIDR entry is the IPv4 setting and the second CIDR entry is the IPv6 setting.

```
machineNetwork:
- cidr: {{ extcidrnet }}
- cidr: {{ extcidrnet6 }}
clusterNetwork:
- cidr: 10.128.0.0/14
  hostPrefix: 23
- cidr: fd02::/48
  hostPrefix: 64
serviceNetwork:
- 172.30.0.0/16
- fd03::/112
```

IMPORTANT

The API VIP IP address and the Ingress VIP address must be of the primary IP address family when using dual-stack networking. Currently, Red Hat does not support dual-stack VIPs or dual-stack networking with IPv6 as the primary IP address family. However, Red Hat does support dual-stack networking with IPv4 as the primary IP address family. Therefore, the IPv4 entries must go **before** the IPv6 entries.

14.3.9.11. Optional: Configuring host network interfaces

Before installation, you can set the **networkConfig** configuration setting in the **install-config.yaml** file to configure host network interfaces using NMState.

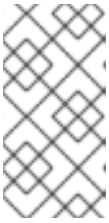
The most common use case for this functionality is to specify a static IP address on the bare-metal network, but you can also configure other networks such as a storage network. This functionality supports other NMState features such as VLAN, VXLAN, bridges, bonds, routes, MTU, and DNS resolver settings.

Prerequisites

- Configure a **PTR** DNS record with a valid hostname for each node with a static IP address.
- Install the NMState CLI (**nmstate**).

Procedure

1. Optional: Consider testing the NMState syntax with **nmstatectl gc** before including it in the **install-config.yaml** file, because the installer will not check the NMState YAML syntax.



NOTE

Errors in the YAML syntax might result in a failure to apply the network configuration. Additionally, maintaining the validated YAML syntax is useful when applying changes using Kubernetes NMState after deployment or when expanding the cluster.

   a. Create an NMState YAML file:

```
interfaces:
- name: <nic1_name> 1
  type: ethernet
  state: up
  ipv4:
    address:
    - ip: <ip_address> 2
      prefix-length: 24
    enabled: true
dns-resolver:
  config:
    server:
    - <dns_ip_address> 3
routes:
  config:
```

```
    - destination: 0.0.0.0/0
      next-hop-address: <next_hop_ip_address> 4
      next-hop-interface: <next_hop_nic1_name> 5
```

1 2 3 4 5 Replace **<nic1_name>**, **<ip_address>**, **<dns_ip_address>**, **<next_hop_ip_address>** and **<next_hop_nic1_name>** with appropriate values.

b. Test the configuration file by running the following command:

```
$ nmstatectl gc <nmstate_yaml_file>
```

Replace **<nmstate_yaml_file>** with the configuration file name.

2. Use the **networkConfig** configuration setting by adding the NMState configuration to hosts within the **install-config.yaml** file:

```
hosts:
  - name: openshift-master-0
    role: master
    bmc:
      address: redfish+http://<out_of_band_ip>/redfish/v1/Systems/
      username: <user>
      password: <password>
      disableCertificateVerification: null
    bootMACAddress: <NIC1_mac_address>
    bootMode: UEFI
    rootDeviceHints:
      deviceName: "/dev/sda"
    networkConfig: 1
      interfaces:
      - name: <nic1_name> 2
        type: ethernet
        state: up
        ipv4:
          address:
          - ip: <ip_address> 3
            prefix-length: 24
          enabled: true
      dns-resolver:
        config:
          server:
          - <dns_ip_address> 4
      routes:
        config:
        - destination: 0.0.0.0/0
          next-hop-address: <next_hop_ip_address> 5
          next-hop-interface: <next_hop_nic1_name> 6
```

1 Add the NMState YAML syntax to configure the host interfaces.

2 3 4 5 6 Replace **<nic1_name>**, **<ip_address>**, **<dns_ip_address>**, **<next_hop_ip_address>** and **<next_hop_nic1_name>** with appropriate values.

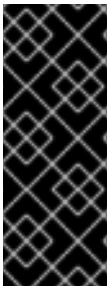
IMPORTANT

After deploying the cluster, you cannot modify the **networkConfig** configuration setting of **install-config.yaml** file to make changes to the host network interface. Use the Kubernetes NMState Operator to make changes to the host network interface after deployment.

14.3.9.12. Configuring host network interfaces for subnets

For edge computing scenarios, it can be beneficial to locate worker nodes closer to the edge. To locate remote worker nodes in subnets, you might use different network segments or subnets for the remote worker nodes than you used for the control plane subnet and local worker nodes. You can reduce latency for the edge and allow for enhanced scalability by setting up subnets for edge computing scenarios.

If you have established different network segments or subnets for remote worker nodes as described in the section on "Establishing communication between subnets", you must specify the subnets in the **machineNetwork** configuration setting if the workers are using static IP addresses, bonds or other advanced networking. When setting the node IP address in the **networkConfig** parameter for each remote worker node, you must also specify the gateway and the DNS server for the subnet containing the control plane nodes when using static IP addresses. This ensures the remote worker nodes can reach the subnet containing the control plane nodes and that they can receive network traffic from the control plane.



IMPORTANT

All control plane nodes must run in the same subnet. When using more than one subnet, you can also configure the Ingress VIP to run on the control plane nodes by using a manifest. See "Configuring network components to run on the control plane" for details.

Deploying a cluster with multiple subnets requires using virtual media, such as **redfish-virtualmedia** and **idrac-virtualmedia**.

Procedure

1. Add the subnets to the **machineNetwork** in the **install-config.yaml** file when using static IP addresses:

```
networking:
  machineNetwork:
  - cidr: 10.0.0.0/24
  - cidr: 192.168.0.0/24
  networkType: OVNKubernetes
```

2. Add the gateway and DNS configuration to the **networkConfig** parameter of each edge worker node using NMState syntax when using a static IP address or advanced networking such as bonds:

```
networkConfig:
  nmstate:
    interfaces:
    - name: <interface_name> 1
      type: ethernet
      state: up
      ipv4:
        enabled: true
```

```
    dhcp: false
    address:
    - ip: <node_ip> 2
      prefix-length: 24
    gateway: <gateway_ip> 3
    dns-resolver:
      config:
        server:
        - <dns_ip> 4
```

1. Replace **<interface_name>** with the interface name.
2. Replace **<node_ip>** with the IP address of the node.
3. Replace **<gateway_ip>** with the IP address of the gateway.
4. Replace **<dns_ip>** with the IP address of the DNS server.

14.3.9.13. Optional: Configuring address generation modes for SLAAC in dual-stack networks

For dual-stack clusters that use Stateless Address AutoConfiguration (SLAAC), you must specify a global value for the **ipv6.addr-gen-mode** network setting. You can set this value using NMState to configure the ramdisk and the cluster configuration files. If you don't configure a consistent **ipv6.addr-gen-mode** in these locations, IPv6 address mismatches can occur between CSR resources and **BareMetalHost** resources in the cluster.

Prerequisites

- Install the NMState CLI (**nmstate**).

Procedure

1. Optional: Consider testing the NMState YAML syntax with the **nmstatectl gc** command before including it in the **install-config.yaml** file because the installation program will not check the NMState YAML syntax.

   a. Create an NMState YAML file:

   ```
   interfaces:
   - name: eth0
     ipv6:
       addr-gen-mode: <address_mode> 1
   ```

   1. Replace **<address_mode>** with the type of address generation mode required for IPv6 addresses in the cluster. Valid values are **eui64**, **stable-privacy**, or **random**.

   b. Test the configuration file by running the following command:

   ```
   $ nmstatectl gc <nmstate_yaml_file> 1
   ```

   1. Replace **<nmstate_yaml_file>** with the name of the test configuration file.

2. Add the NMState configuration to the **hosts.networkConfig** section within the install-config.yaml file:

```
    hosts:
      - name: openshift-master-0
        role: master
        bmc:
          address: redfish+http://<out_of_band_ip>/redfish/v1/Systems/
          username: <user>
          password: <password>
          disableCertificateVerification: null
        bootMACAddress: <NIC1_mac_address>
        bootMode: UEFI
        rootDeviceHints:
          deviceName: "/dev/sda"
        networkConfig:
          interfaces:
          - name: eth0
            ipv6:
              addr-gen-mode: <address_mode> 1
...
```

1 Replace **<address_mode>** with the type of address generation mode required for IPv6 addresses in the cluster. Valid values are **eui64**, **stable-privacy**, or **random**.

14.3.9.14. Configuring multiple cluster nodes

You can simultaneously configure OpenShift Container Platform cluster nodes with identical settings. Configuring multiple cluster nodes avoids adding redundant information for each node to the **install-config.yaml** file. This file contains specific parameters to apply an identical configuration to multiple nodes in the cluster.

Compute nodes are configured separately from the controller node. However, configurations for both node types use the highlighted parameters in the **install-config.yaml** file to enable multi-node configuration. Set the **networkConfig** parameters to **BOND**, as shown in the following example:

```
hosts:
- name: ostest-master-0
 [...]
 networkConfig: &BOND
   interfaces:
   - name: bond0
     type: bond
     state: up
     ipv4:
       dhcp: true
       enabled: true
     link-aggregation:
       mode: active-backup
       port:
       - enp2s0
       - enp3s0
- name: ostest-master-1
 [...]
```

```
  networkConfig: *BOND
- name: ostest-master-2
  [...]
  networkConfig: *BOND
```

NOTE

Configuration of multiple cluster nodes is only available for initial deployments on installer-provisioned infrastructure.

14.3.9.15. Optional: Configuring managed Secure Boot

You can enable managed Secure Boot when deploying an installer-provisioned cluster using Redfish BMC addressing, such as **redfish**, **redfish-virtualmedia**, or **idrac-virtualmedia**. To enable managed Secure Boot, add the **bootMode** configuration setting to each node:

Example

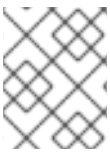
```
hosts:
  - name: openshift-master-0
    role: master
    bmc:
      address: redfish://<out_of_band_ip> (1)
      username: <username>
      password: <password>
    bootMACAddress: <NIC1_mac_address>
    rootDeviceHints:
     deviceName: "/dev/sda"
    bootMode: UEFISecureBoot (2)
```

(1) Ensure the **bmc.address** setting uses **redfish**, **redfish-virtualmedia**, or **idrac-virtualmedia** as the protocol. See "BMC addressing for HPE iLO" or "BMC addressing for Dell iDRAC" for additional details.

(2) The **bootMode** setting is **UEFI** by default. Change it to **UEFISecureBoot** to enable managed Secure Boot.

NOTE

See "Configuring nodes" in the "Prerequisites" to ensure the nodes can support managed Secure Boot. If the nodes do not support managed Secure Boot, see "Configuring nodes for Secure Boot manually" in the "Configuring nodes" section. Configuring Secure Boot manually requires Redfish virtual media.



NOTE

Red Hat does not support Secure Boot with IPMI, because IPMI does not provide Secure Boot management facilities.

14.3.10. Manifest configuration files

14.3.10.1. Creating the OpenShift Container Platform manifests

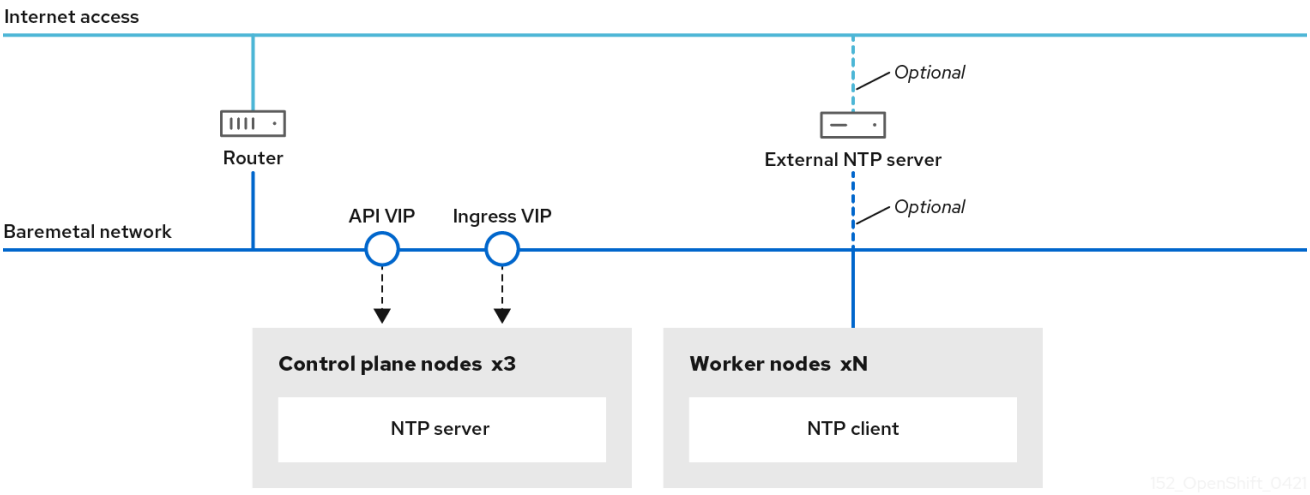
1. Create the OpenShift Container Platform manifests.

```
$ ./openshift-baremetal-install --dir ~/clusterconfigs create manifests
```

```
INFO Consuming Install Config from target directory
WARNING Making control-plane schedulable by setting MastersSchedulable to true for
Scheduler cluster settings
WARNING Discarding the OpenShift Manifest that was provided in the target directory
because its dependencies are dirty and it needs to be regenerated
```

14.3.10.2. Optional: Configuring NTP for disconnected clusters

OpenShift Container Platform installs the **chrony** Network Time Protocol (NTP) service on the cluster nodes.



OpenShift Container Platform nodes must agree on a date and time to run properly. When worker nodes retrieve the date and time from the NTP servers on the control plane nodes, it enables the installation and operation of clusters that are not connected to a routable network and thereby do not have access to a higher stratum NTP server.

Procedure

1. Create a Butane config, **99-master-chrony-conf-override.bu**, including the contents of the **chrony.conf** file for the control plane nodes.

NOTE

See "Creating machine configs with Butane" for information about Butane.

Butane config example

```
variant: openshift
version: 4.11.0
metadata:
  name: 99-master-chrony-conf-override
  labels:
    machineconfiguration.openshift.io/role: master
```

```
storage:
  files:
    - path: /etc/chrony.conf
      mode: 0644
      overwrite: true
      contents:
        inline: |
          # Use public servers from the pool.ntp.org project.
          # Please consider joining the pool (https://www.pool.ntp.org/join.html).

          # The Machine Config Operator manages this file
          server openshift-master-0.<cluster-name>.<domain> iburst 1
          server openshift-master-1.<cluster-name>.<domain> iburst
          server openshift-master-2.<cluster-name>.<domain> iburst

          stratumweight 0
          driftfile /var/lib/chrony/drift
          rtcsync
          makestep 10 3
          bindcmdaddress 127.0.0.1
          bindcmdaddress ::1
          keyfile /etc/chrony.keys
          commandkey 1
          generatecommandkey
          noclientlog
          logchange 0.5
          logdir /var/log/chrony

          # Configure the control plane nodes to serve as local NTP servers
          # for all worker nodes, even if they are not in sync with an
          # upstream NTP server.

          # Allow NTP client access from the local network.
          allow all
          # Serve time even if not synchronized to a time source.
          local stratum 3 orphan
```

1 You must replace **<cluster-name>** with the name of the cluster and replace **<domain>** with the fully qualified domain name.

2. Use Butane to generate a **MachineConfig** object file, **99-master-chrony-conf-override.yaml**, containing the configuration to be delivered to the control plane nodes:

```
$ butane 99-master-chrony-conf-override.bu -o 99-master-chrony-conf-override.yaml
```

3. Create a Butane config, **99-worker-chrony-conf-override.bu**, including the contents of the **chrony.conf** file for the worker nodes that references the NTP servers on the control plane nodes.

Butane config example

```
variant: openshift
version: 4.11.0
metadata:
```

```
  name: 99-worker-chrony-conf-override
  labels:
    machineconfiguration.openshift.io/role: worker
storage:
  files:
    - path: /etc/chrony.conf
      mode: 0644
      overwrite: true
      contents:
        inline: |
          # The Machine Config Operator manages this file.
          server openshift-master-0.<cluster-name>.<domain> iburst 1
          server openshift-master-1.<cluster-name>.<domain> iburst
          server openshift-master-2.<cluster-name>.<domain> iburst

          stratumweight 0
          driftfile /var/lib/chrony/drift
          rtcsync
          makestep 10 3
          bindcmdaddress 127.0.0.1
          bindcmdaddress ::1
          keyfile /etc/chrony.keys
          commandkey 1
          generatecommandkey
          noclientlog
          logchange 0.5
          logdir /var/log/chrony
```

1 You must replace **<cluster-name>** with the name of the cluster and replace **<domain>** with the fully qualified domain name.

4. Use Butane to generate a **MachineConfig** object file, **99-worker-chrony-conf-override.yaml**, containing the configuration to be delivered to the worker nodes:

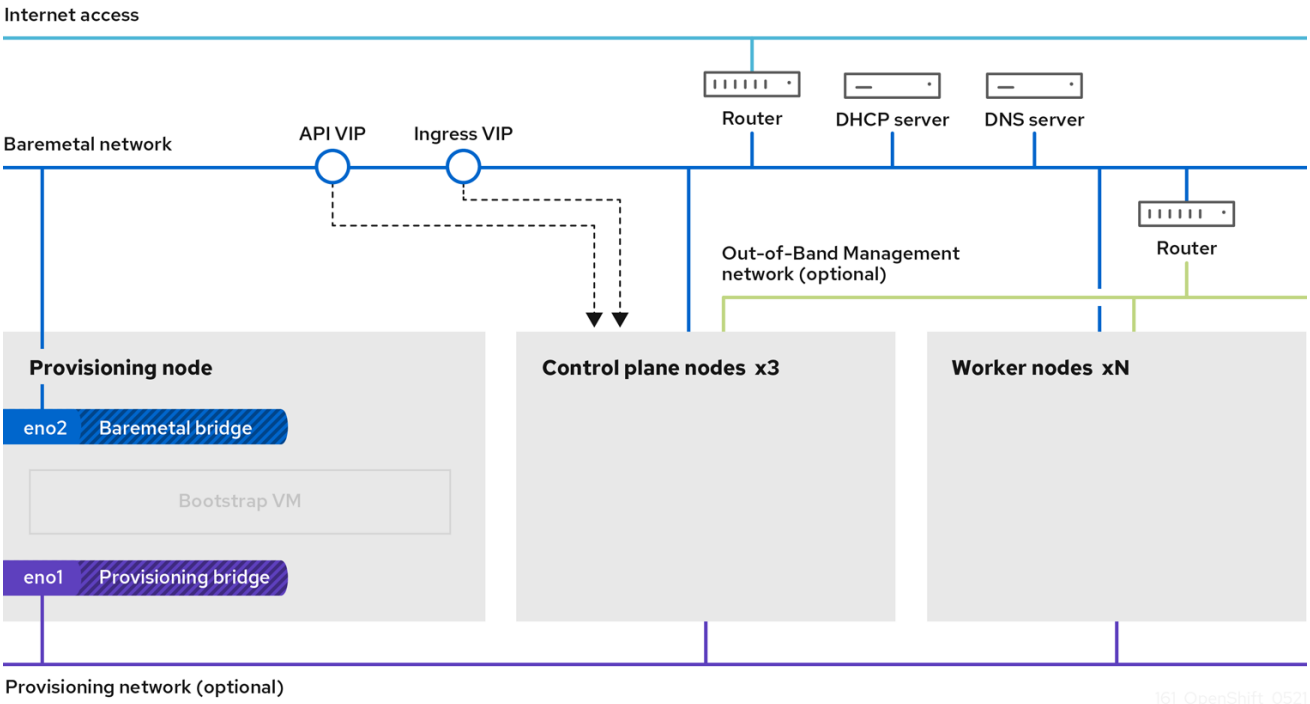
```
$ butane 99-worker-chrony-conf-override.bu -o 99-worker-chrony-conf-override.yaml
```

14.3.10.3. Configuring network components to run on the control plane

You can configure networking components to run exclusively on the control plane nodes. By default, OpenShift Container Platform allows any node in the machine config pool to host the **ingressVIP** virtual IP address. However, some environments deploy worker nodes in separate subnets from the control plane nodes, which requires configuring the **ingressVIP** virtual IP address to run on the control plane nodes.

IMPORTANT

When deploying remote workers in separate subnets, you must place the **ingressVIP** virtual IP address exclusively with the control plane nodes.



Procedure

1. Change to the directory storing the **install-config.yaml** file:

```
$ cd ~/clusterconfigs
```

2. Switch to the **manifests** subdirectory:

```
$ cd manifests
```

3. Create a file named **cluster-network-avoid-workers-99-config.yaml**:

```
$ touch cluster-network-avoid-workers-99-config.yaml
```

4. Open the **cluster-network-avoid-workers-99-config.yaml** file in an editor and enter a custom resource (CR) that describes the Operator configuration:

```
apiVersion: machineconfiguration.openshift.io/v1
kind: MachineConfig
metadata:
  name: 50-worker-fix-ipi-rwn
  labels:
    machineconfiguration.openshift.io/role: worker
spec:
  config:
    ignition:
      version: 3.2.0
    storage:
      files:
        - path: /etc/kubernetes/manifests/keepalived.yaml
```

```
      mode: 0644
      contents:
        source: data:,
```

This manifest places the **ingressVIP** virtual IP address on the control plane nodes. Additionally, this manifest deploys the following processes on the control plane nodes only:

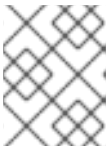
- **openshift-ingress-operator**
- **keepalived**

5. Save the **cluster-network-avoid-workers-99-config.yaml** file.
6. Create a **manifests/cluster-ingress-default-ingresscontroller.yaml** file:

```
apiVersion: operator.openshift.io/v1
kind: IngressController
metadata:
  name: default
  namespace: openshift-ingress-operator
spec:
  nodePlacement:
    nodeSelector:
      matchLabels:
        node-role.kubernetes.io/master: ""
```

7. Consider backing up the **manifests** directory. The installer deletes the **manifests/** directory when creating the cluster.
8. Modify the **cluster-scheduler-02-config.yml** manifest to make the control plane nodes schedulable by setting the **mastersSchedulable** field to **true**. Control plane nodes are not schedulable by default. For example:

```
$ sed -i "s;mastersSchedulable: false;mastersSchedulable: true;g"
clusterconfigs/manifests/cluster-scheduler-02-config.yml
```



NOTE

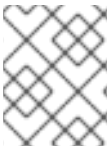
If control plane nodes are not schedulable after completing this procedure, deploying the cluster will fail.

14.3.10.4. Optional: Deploying routers on worker nodes

During installation, the installer deploys router pods on worker nodes. By default, the installer installs two router pods. If a deployed cluster requires additional routers to handle external traffic loads destined for services within the OpenShift Container Platform cluster, you can create a **yaml** file to set an appropriate number of router replicas.

IMPORTANT

Deploying a cluster with only one worker node is not supported. While modifying the router replicas will address issues with the **degraded** state when deploying with one worker, the cluster loses high availability for the ingress API, which is not suitable for production environments.



NOTE

By default, the installer deploys two routers. If the cluster has no worker nodes, the installer deploys the two routers on the control plane nodes by default.

Procedure

1. Create a **router-replicas.yaml** file:

```
apiVersion: operator.openshift.io/v1
kind: IngressController
metadata:
  name: default
  namespace: openshift-ingress-operator
spec:
  replicas: <num-of-router-pods>
  endpointPublishingStrategy:
    type: HostNetwork
  nodePlacement:
    nodeSelector:
      matchLabels:
        node-role.kubernetes.io/worker: ""
```

NOTE

Replace **<num-of-router-pods>** with an appropriate value. If working with just one worker node, set **replicas:** to **1**. If working with more than 3 worker nodes, you can increase **replicas:** from the default value **2** as appropriate.

2. Save and copy the **router-replicas.yaml** file to the **clusterconfigs/openshift** directory:

```
$ cp ~/router-replicas.yaml clusterconfigs/openshift/99_router-replicas.yaml
```

14.3.10.5. Optional: Configuring the BIOS

The following procedure configures the BIOS during the installation process.

Procedure

1. Create the manifests.
2. Modify the **BareMetalHost** resource file corresponding to the node:

```
$ vim clusterconfigs/openshift/99_openshift-cluster-api_hosts-*.yaml
```

3. Add the BIOS configuration to the **spec** section of the **BareMetalHost** resource:

```
spec:
  firmware:
    simultaneousMultithreadingEnabled: true
    sriovEnabled: true
    virtualizationEnabled: true
```

NOTE

Red Hat supports three BIOS configurations. Only servers with BMC type **irmc** are supported. Other types of servers are currently not supported.

4. Create the cluster.

Additional resources

- Bare metal configuration

14.3.10.6. Optional: Configuring the RAID

The following procedure configures a redundant array of independent disks (RAID) during the installation process.

NOTE

1. OpenShift Container Platform supports hardware RAID for baseboard management controllers (BMCs) using the iRMC protocol only. OpenShift Container Platform 4.11 does not support software RAID.
2. If you want to configure a hardware RAID for the node, verify that the node has a RAID controller.

Procedure

1. Create the manifests.
2. Modify the **BareMetalHost** resource corresponding to the node:

```
$ vim clusterconfigs/openshift/99_openshift-cluster-api_hosts-*.yaml
```

NOTE

The following example uses a hardware RAID configuration because OpenShift Container Platform 4.11 does not support software RAID.

a. If you added a specific RAID configuration to the **spec** section, this causes the node to delete the original RAID configuration in the **preparing** phase and perform a specified configuration on the RAID. For example:

```
spec:
  raid:
    hardwareRAIDVolumes:
    - level: "0" (1)
      name: "sda"
      numberOfPhysicalDisks: 1
      rotational: true
      sizeGibibytes: 0
```

(1) **level** is a required field, and the others are optional fields.

b. If you added an empty RAID configuration to the **spec** section, the empty configuration causes the node to delete the original RAID configuration during the **preparing** phase, but does not perform a new configuration. For example:

```
spec:
  raid:
    hardwareRAIDVolumes: []
```

c. If you do not add a **raid** field in the **spec** section, the original RAID configuration is not deleted, and no new configuration will be performed.

3. Create the cluster.

Additional resources

- Bare metal configuration

14.3.11. Creating a disconnected registry

In some cases, you might want to install an OpenShift Container Platform cluster using a local copy of the installation registry. This could be for enhancing network efficiency because the cluster nodes are on a network that does not have access to the internet.

A local, or mirrored, copy of the registry requires the following:

- A certificate for the registry node. This can be a self-signed certificate.
- A web server that a container on a system will serve.
- An updated pull secret that contains the certificate and local repository information.

NOTE

Creating a disconnected registry on a registry node is optional. If you need to create a disconnected registry on a registry node, you must complete all of the following sub-sections.

Prerequisites

- If you have already prepared a mirror registry for Mirroring images for a disconnected installation, you can skip directly to Modify the install-config.yaml file to use the disconnected registry.

14.3.11.1. Preparing the registry node to host the mirrored registry

The following steps must be completed prior to hosting a mirrored registry on bare metal.

Procedure

1. Open the firewall port on the registry node:

```
$ sudo firewall-cmd --add-port=5000/tcp --zone=libvirt  --permanent
```

```
$ sudo firewall-cmd --add-port=5000/tcp --zone=public   --permanent
```

–

```
$ sudo firewall-cmd --reload
```

2. Install the required packages for the registry node:

```
$ sudo yum -y install python3 podman httpd httpd-tools jq
```

3. Create the directory structure where the repository information will be held:

```
$ sudo mkdir -p /opt/registry/{auth,certs,data}
```

14.3.11.2. Mirroring the OpenShift Container Platform image repository for a disconnected registry

Complete the following steps to mirror the OpenShift Container Platform image repository for a disconnected registry.

Prerequisites

- Your mirror host has access to the internet.
- You configured a mirror registry to use in your restricted network and can access the certificate and credentials that you configured.
- You downloaded the pull secret from the Red Hat OpenShift Cluster Manager and modified it to include authentication to your mirror repository.

Procedure

1. Review the OpenShift Container Platform downloads page to determine the version of OpenShift Container Platform that you want to install and determine the corresponding tag on the Repository Tags page.
2. Set the required environment variables:
   a. Export the release version:

```
$ OCP_RELEASE=<release_version>
```

   For **<release_version>**, specify the tag that corresponds to the version of OpenShift Container Platform to install, such as **4.5.4**.

   b. Export the local registry name and host port:

```
$ LOCAL_REGISTRY='<local_registry_host_name>:<local_registry_host_port>'
```

   For **<local_registry_host_name>**, specify the registry domain name for your mirror repository, and for **<local_registry_host_port>**, specify the port that it serves content on.

   c. Export the local repository name:

```
$ LOCAL_REPOSITORY='<local_repository_name>'
```

For **<local_repository_name>**, specify the name of the repository to create in your registry, such as **ocp4/openshift4**.

d. Export the name of the repository to mirror:

```
$ PRODUCT_REPO='openshift-release-dev'
```

For a production release, you must specify **openshift-release-dev**.

e. Export the path to your registry pull secret:

```
$ LOCAL_SECRET_JSON='<path_to_pull_secret>'
```

For **<path_to_pull_secret>**, specify the absolute path to and file name of the pull secret for your mirror registry that you created.

f. Export the release mirror:

```
$ RELEASE_NAME="ocp-release"
```

For a production release, you must specify **ocp-release**.

g. Export the type of architecture for your server, such as **x86_64**:

```
$ ARCHITECTURE=<server_architecture>
```

h. Export the path to the directory to host the mirrored images:

```
$ REMOVABLE_MEDIA_PATH=<path> 1
```

1 Specify the full path, including the initial forward slash (/) character.

3. Mirror the version images to the mirror registry:

- If your mirror host does not have internet access, take the following actions:

i. Connect the removable media to a system that is connected to the internet.

ii. Review the images and configuration manifests to mirror:

```
$ oc adm release mirror -a ${LOCAL_SECRET_JSON}  \
    --from=quay.io/${PRODUCT_REPO}/${RELEASE_NAME}:${OCP_RELEASE}-
${ARCHITECTURE} \
    --to=${LOCAL_REGISTRY}/${LOCAL_REPOSITORY} \
    --to-release-
image=${LOCAL_REGISTRY}/${LOCAL_REPOSITORY}:${OCP_RELEASE}-
${ARCHITECTURE} --dry-run
```

iii. Record the entire **imageContentSources** section from the output of the previous command. The information about your mirrors is unique to your mirrored repository, and you must add the **imageContentSources** section to the **install-config.yaml** file during installation.

iv. Mirror the images to a directory on the removable media:

```
$ oc adm release mirror -a ${LOCAL_SECRET_JSON} --to-
dir=${REMOVABLE_MEDIA_PATH}/mirror
quay.io/${PRODUCT_REPO}/${RELEASE_NAME}:${OCP_RELEASE}-
${ARCHITECTURE}
```

v. Take the media to the restricted network environment and upload the images to the local container registry.

```
$ oc image mirror -a ${LOCAL_SECRET_JSON} --from-
dir=${REMOVABLE_MEDIA_PATH}/mirror
"file://openshift/release:${OCP_RELEASE}*"
${LOCAL_REGISTRY}/${LOCAL_REPOSITORY} 1
```

1 For **REMOVABLE_MEDIA_PATH**, you must use the same path that you specified when you mirrored the images.

- If the local container registry is connected to the mirror host, take the following actions:

i. Directly push the release images to the local registry by using following command:

```
$ oc adm release mirror -a ${LOCAL_SECRET_JSON}  \
    --from=quay.io/${PRODUCT_REPO}/${RELEASE_NAME}:${OCP_RELEASE}-
${ARCHITECTURE} \
    --to=${LOCAL_REGISTRY}/${LOCAL_REPOSITORY} \
    --to-release-
image=${LOCAL_REGISTRY}/${LOCAL_REPOSITORY}:${OCP_RELEASE}-
${ARCHITECTURE}
```

This command pulls the release information as a digest, and its output includes the **imageContentSources** data that you require when you install your cluster.

ii. Record the entire **imageContentSources** section from the output of the previous command. The information about your mirrors is unique to your mirrored repository, and you must add the **imageContentSources** section to the **install-config.yaml** file during installation.

NOTE

The image name gets patched to Quay.io during the mirroring process, and the podman images will show Quay.io in the registry on the bootstrap virtual machine.

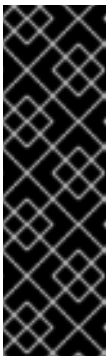
4. To create the installation program that is based on the content that you mirrored, extract it and pin it to the release:

- If your mirror host does not have internet access, run the following command:

```
$ oc adm release extract -a ${LOCAL_SECRET_JSON} --command=openshift-
baremetal-install "${LOCAL_REGISTRY}/${LOCAL_REPOSITORY}:${OCP_RELEASE}"
```

- If the local container registry is connected to the mirror host, run the following command:

```
$ oc adm release extract -a ${LOCAL_SECRET_JSON} --command=openshift-
baremetal-install "${LOCAL_REGISTRY}/${LOCAL_REPOSITORY}:${OCP_RELEASE}-
${ARCHITECTURE}"
```



IMPORTANT

To ensure that you use the correct images for the version of OpenShift Container Platform that you selected, you must extract the installation program from the mirrored content.

You must perform this step on a machine with an active internet connection.

If you are in a disconnected environment, use the **--image** flag as part of must-gather and point to the payload image.

5. For clusters using installer-provisioned infrastructure, run the following command:

```
$ openshift-baremetal-install
```

14.3.11.3. Modify the install-config.yaml file to use the disconnected registry

On the provisioner node, the **install-config.yaml** file should use the newly created pull-secret from the **pull-secret-update.txt** file. The **install-config.yaml** file must also contain the disconnected registry node's certificate and registry information.

Procedure

1. Add the disconnected registry node's certificate to the **install-config.yaml** file:

```
$ echo "additionalTrustBundle: |" >> install-config.yaml
```

The certificate should follow the **"additionalTrustBundle: |"** line and be properly indented, usually by two spaces.

```
$ sed -e 's/^/  /' /opt/registry/certs/domain.crt >> install-config.yaml
```

2. Add the mirror information for the registry to the **install-config.yaml** file:

```
$ echo "imageContentSources:" >> install-config.yaml
```

```
$ echo "- mirrors:" >> install-config.yaml
```

```
$ echo "  - registry.example.com:5000/ocp4/openshift4" >> install-config.yaml
```

Replace **registry.example.com** with the registry's fully qualified domain name.

```
$ echo "  source: quay.io/openshift-release-dev/ocp-release" >> install-config.yaml
```

```
$ echo "- mirrors:" >> install-config.yaml
```

```
$ echo "  - registry.example.com:5000/ocp4/openshift4" >> install-config.yaml
```

Replace **registry.example.com** with the registry's fully qualified domain name.

```
$ echo "  source: quay.io/openshift-release-dev/ocp-v4.0-art-dev" >> install-config.yaml
```

14.3.12. Validation checklist for installation

❑ OpenShift Container Platform installer has been retrieved.

❑ OpenShift Container Platform installer has been extracted.

❑ Required parameters for the **install-config.yaml** have been configured.

❑ The **hosts** parameter for the **install-config.yaml** has been configured.

❑ The **bmc** parameter for the **install-config.yaml** has been configured.

❑ Conventions for the values configured in the **bmc address** field have been applied.

❑ Created the OpenShift Container Platform manifests.

❑ (Optional) Deployed routers on worker nodes.

❑ (Optional) Created a disconnected registry.

❑ (Optional) Validate disconnected registry settings if in use.

14.3.13. Deploying the cluster via the OpenShift Container Platform installer

Run the OpenShift Container Platform installer:

```
$ ./openshift-baremetal-install --dir ~/clusterconfigs --log-level debug create cluster
```

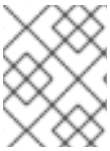
14.3.14. Following the installation

During the deployment process, you can check the installation's overall status by issuing the **tail** command to the **.openshift_install.log** log file in the install directory folder:

```
$ tail -f /path/to/install-dir/.openshift_install.log
```

14.3.15. Verifying static IP address configuration

If the DHCP reservation for a cluster node specifies an infinite lease, after the installer successfully provisions the node, the dispatcher script checks the node's network configuration. If the script determines that the network configuration contains an infinite DHCP lease, it creates a new connection using the IP address of the DHCP lease as a static IP address.



NOTE

The dispatcher script might run on successfully provisioned nodes while the provisioning of other nodes in the cluster is ongoing.

Verify the network configuration is working properly.

Procedure

1. Check the network interface configuration on the node.
2. Turn off the DHCP server and reboot the OpenShift Container Platform node and ensure that the network configuration works properly.

14.3.16. Preparing to reinstall a cluster on bare metal

Before you reinstall a cluster on bare metal, you must perform cleanup operations.

Procedure

1. Remove or reformat the disks for the bootstrap, control plane node, and worker nodes. If you are working in a hypervisor environment, you must add any disks you removed.
2. Delete the artifacts that the previous installation generated:

```
$ cd ; /bin/rm -rf auth/ bootstrap.ign master.ign worker.ign metadata.json \
.openshift_install.log .openshift_install_state.json
```

3. Generate new manifests and Ignition config files. See “Creating the Kubernetes manifest and Ignition config files" for more information.
4. Upload the new bootstrap, control plane, and compute node Ignition config files that the installation program created to your HTTP server. This will overwrite the previous Ignition files.

14.3.17. Additional resources

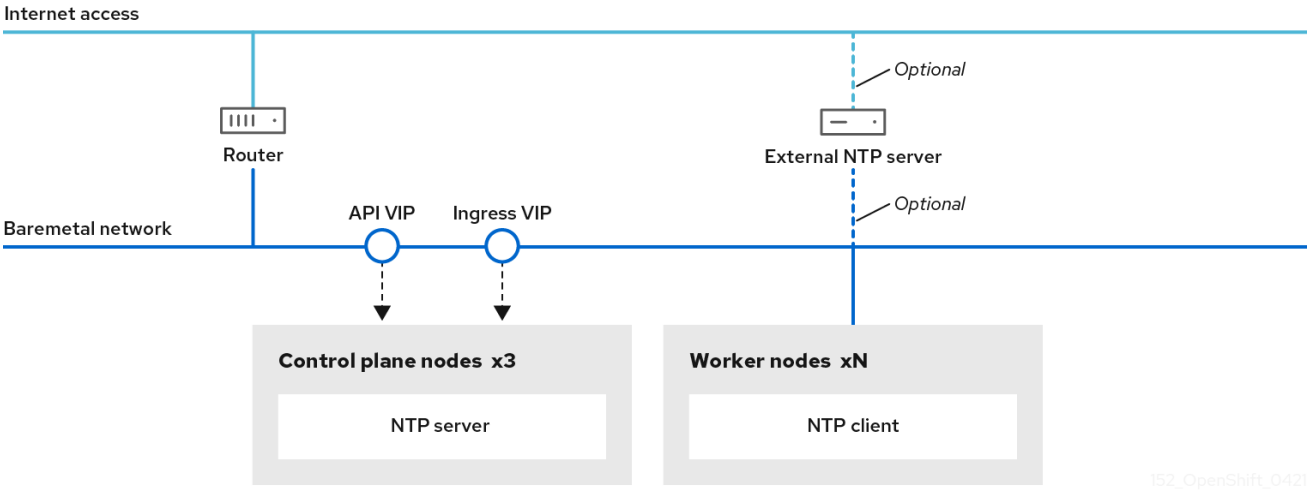
- OpenShift Container Platform Creating the Kubernetes manifest and Ignition config files
- Understanding update channels and releases

14.4. INSTALLER-PROVISIONED POSTINSTALLATION CONFIGURATION

After successfully deploying an installer-provisioned cluster, consider the following postinstallation procedures.

14.4.1. Optional: Configuring NTP for disconnected clusters

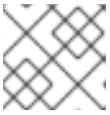
OpenShift Container Platform installs the **chrony** Network Time Protocol (NTP) service on the cluster nodes. Use the following procedure to configure NTP servers on the control plane nodes and configure worker nodes as NTP clients of the control plane nodes after a successful deployment.



OpenShift Container Platform nodes must agree on a date and time to run properly. When worker nodes retrieve the date and time from the NTP servers on the control plane nodes, it enables the installation and operation of clusters that are not connected to a routable network and thereby do not have access to a higher stratum NTP server.

Procedure

1. Create a Butane config, **99-master-chrony-conf-override.bu**, including the contents of the **chrony.conf** file for the control plane nodes.



NOTE

See "Creating machine configs with Butane" for information about Butane.

Butane config example

```
variant: openshift
version: 4.11.0
metadata:
  name: 99-master-chrony-conf-override
  labels:
    machineconfiguration.openshift.io/role: master
storage:
  files:
    - path: /etc/chrony.conf
      mode: 0644
      overwrite: true
      contents:
        inline: |
          # Use public servers from the pool.ntp.org project.
          # Please consider joining the pool (https://www.pool.ntp.org/join.html).

          # The Machine Config Operator manages this file
          server openshift-master-0.<cluster-name>.<domain> iburst 1
          server openshift-master-1.<cluster-name>.<domain> iburst
          server openshift-master-2.<cluster-name>.<domain> iburst

          stratumweight 0
```

```
    driftfile /var/lib/chrony/drift
    rtcsync
    makestep 10 3
    bindcmdaddress 127.0.0.1
    bindcmdaddress ::1
    keyfile /etc/chrony.keys
    commandkey 1
    generatecommandkey
    noclientlog
    logchange 0.5
    logdir /var/log/chrony

    # Configure the control plane nodes to serve as local NTP servers
    # for all worker nodes, even if they are not in sync with an
    # upstream NTP server.

    # Allow NTP client access from the local network.
    allow all
    # Serve time even if not synchronized to a time source.
    local stratum 3 orphan
```

1 You must replace **<cluster-name>** with the name of the cluster and replace **<domain>** with the fully qualified domain name.

2. Use Butane to generate a **MachineConfig** object file, **99-master-chrony-conf-override.yaml**, containing the configuration to be delivered to the control plane nodes:

```
$ butane 99-master-chrony-conf-override.bu -o 99-master-chrony-conf-override.yaml
```

3. Create a Butane config, **99-worker-chrony-conf-override.bu**, including the contents of the **chrony.conf** file for the worker nodes that references the NTP servers on the control plane nodes.

Butane config example

```
variant: openshift
version: 4.11.0
metadata:
  name: 99-worker-chrony-conf-override
  labels:
    machineconfiguration.openshift.io/role: worker
storage:
  files:
    - path: /etc/chrony.conf
      mode: 0644
      overwrite: true
      contents:
        inline: |
          # The Machine Config Operator manages this file.
          server openshift-master-0.<cluster-name>.<domain> iburst 1
          server openshift-master-1.<cluster-name>.<domain> iburst
          server openshift-master-2.<cluster-name>.<domain> iburst

          stratumweight 0
```

```
    driftfile /var/lib/chrony/drift
    rtcsync
    makestep 10 3
    bindcmdaddress 127.0.0.1
    bindcmdaddress ::1
    keyfile /etc/chrony.keys
    commandkey 1
    generatecommandkey
    noclientlog
    logchange 0.5
    logdir /var/log/chrony
```

1. You must replace **<cluster-name>** with the name of the cluster and replace **<domain>** with the fully qualified domain name.

4. Use Butane to generate a **MachineConfig** object file, **99-worker-chrony-conf-override.yaml**, containing the configuration to be delivered to the worker nodes:

```
$ butane 99-worker-chrony-conf-override.bu -o 99-worker-chrony-conf-override.yaml
```

5. Apply the **99-master-chrony-conf-override.yaml** policy to the control plane nodes.

```
$ oc apply -f 99-master-chrony-conf-override.yaml
```

Example output

```
machineconfig.machineconfiguration.openshift.io/99-master-chrony-conf-override created
```

6. Apply the **99-worker-chrony-conf-override.yaml** policy to the worker nodes.

```
$ oc apply -f 99-worker-chrony-conf-override.yaml
```

Example output

```
machineconfig.machineconfiguration.openshift.io/99-worker-chrony-conf-override created
```

7. Check the status of the applied NTP settings.

```
$ oc describe machineconfigpool
```

14.4.2. Enabling a provisioning network after installation

The assisted installer and installer-provisioned installation for bare metal clusters provide the ability to deploy a cluster without a **provisioning** network. This capability is for scenarios such as proof-of-concept clusters or deploying exclusively with Redfish virtual media when each node's baseboard management controller is routable via the **baremetal** network.

You can enable a **provisioning** network after installation using the Cluster Baremetal Operator (CBO).

Prerequisites

- A dedicated physical network must exist, connected to all worker and control plane nodes.
- You must isolate the native, untagged physical network.
- The network cannot have a DHCP server when the **provisioningNetwork** configuration setting is set to **Managed**.
- You can omit the **provisioningInterface** setting in OpenShift Container Platform 4.10 to use the **bootMACAddress** configuration setting.

Procedure

1. When setting the **provisioningInterface** setting, first identify the provisioning interface name for the cluster nodes. For example, **eth0** or **eno1**.
2. Enable the Preboot eXecution Environment (PXE) on the **provisioning** network interface of the cluster nodes.
3. Retrieve the current state of the **provisioning** network and save it to a provisioning custom resource (CR) file:

```
$ oc get provisioning -o yaml > enable-provisioning-nw.yaml
```

4. Modify the provisioning CR file:

```
$ vim ~/enable-provisioning-nw.yaml
```

Scroll down to the **provisioningNetwork** configuration setting and change it from **Disabled** to **Managed**. Then, add the **provisioningIP**, **provisioningNetworkCIDR**, **provisioningDHCPRange**, **provisioningInterface**, and **watchAllNameSpaces** configuration settings after the **provisioningNetwork** setting. Provide appropriate values for each setting.

```
apiVersion: v1
items:
- apiVersion: metal3.io/v1alpha1
  kind: Provisioning
  metadata:
    name: provisioning-configuration
  spec:
    provisioningNetwork: 1
    provisioningIP: 2
    provisioningNetworkCIDR: 3
    provisioningDHCPRange: 4
    provisioningInterface: 5
    watchAllNameSpaces: 6
```

1. The **provisioningNetwork** is one of **Managed**, **Unmanaged**, or **Disabled**. When set to **Managed**, Metal3 manages the provisioning network and the CBO deploys the Metal3 pod with a configured DHCP server. When set to **Unmanaged**, the system administrator configures the DHCP server manually.
2. The **provisioningIP** is the static IP address that the DHCP server and ironic use to provision the network. This static IP address must be within the **provisioning** subnet, and outside of the DHCP range. If you configure this setting, it must have a valid IP address

even if the **provisioning** network is **Disabled**. The static IP address is bound to the metal3 pod. If the metal3 pod fails and moves to another server, the static IP address also moves to the new server.

3 The Classless Inter-Domain Routing (CIDR) address. If you configure this setting, it must have a valid CIDR address even if the **provisioning** network is **Disabled**. For example: **192.168.0.1/24**.

4 The DHCP range. This setting is only applicable to a **Managed** provisioning network. Omit this configuration setting if the **provisioning** network is **Disabled**. For example: **192.168.0.64, 192.168.0.253**.

5 The NIC name for the **provisioning** interface on cluster nodes. The **provisioningInterface** setting is only applicable to **Managed** and **Unmanaged** provisioning networks. Omit the **provisioningInterface** configuration setting if the **provisioning** network is **Disabled**. Omit the **provisioningInterface** configuration setting to use the **bootMACAddress** configuration setting instead.

6 Set this setting to **true** if you want metal3 to watch namespaces other than the default **openshift-machine-api** namespace. The default value is **false**.

5. Save the changes to the provisioning CR file.
6. Apply the provisioning CR file to the cluster:

```
$ oc apply -f enable-provisioning-nw.yaml
```

14.4.3. Configuring an external load balancer

You can configure an OpenShift Container Platform cluster to use an external load balancer in place of the default load balancer.

IMPORTANT

Configuring an external load balancer depends on your vendor's load balancer.

The information and examples in this section are for guideline purposes only. Consult the vendor documentation for more specific information about the vendor's load balancer.

Red Hat supports the following services for an external load balancer:

- Ingress Controller
- OpenShift API
- OpenShift MachineConfig API

You can choose whether you want to configure one or all of these services for an external load balancer. Configuring only the Ingress Controller service is a common configuration option. To better understand each service, view the following diagrams:

Figure 14.1. Example network workflow that shows an Ingress Controller operating in an OpenShift Container Platform environment

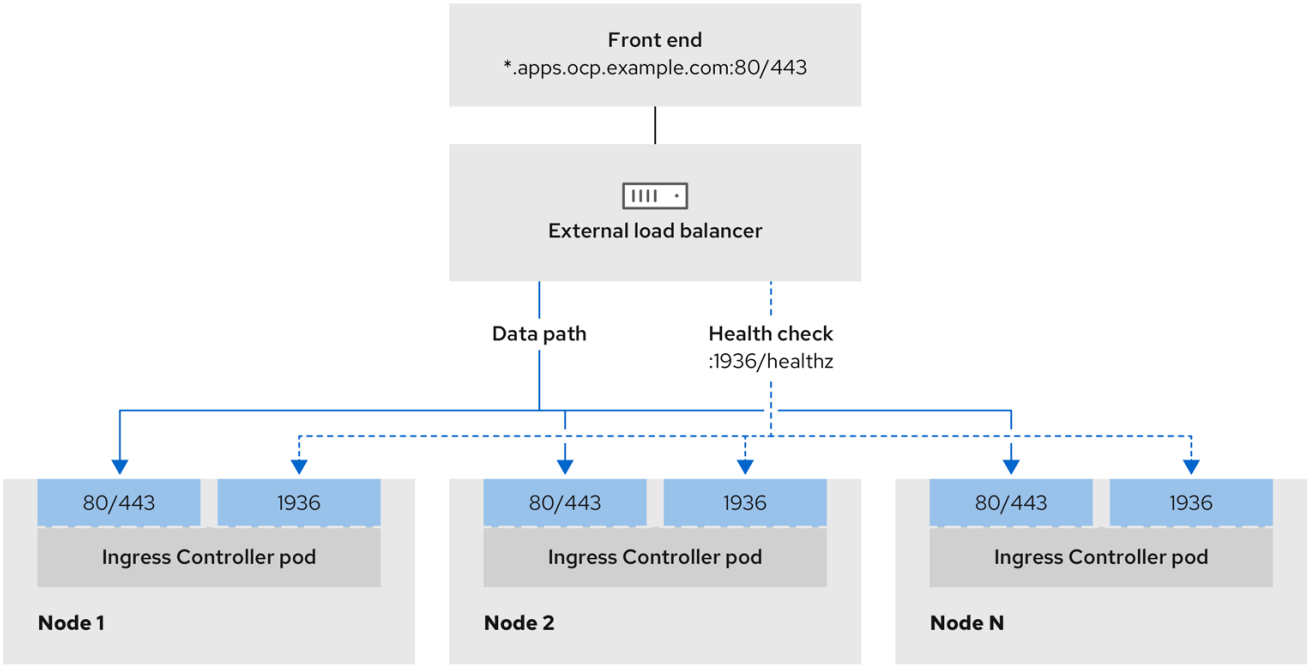


Figure 14.2. Example network workflow that shows an OpenShift API operating in an OpenShift Container Platform environment

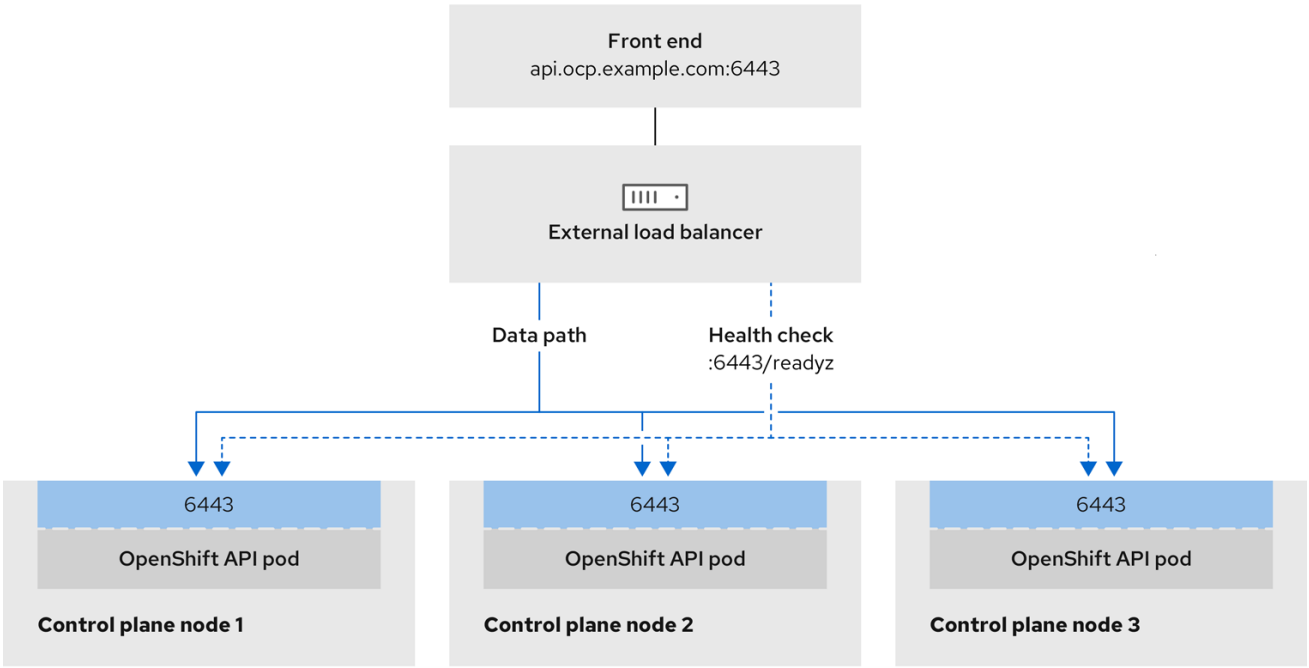
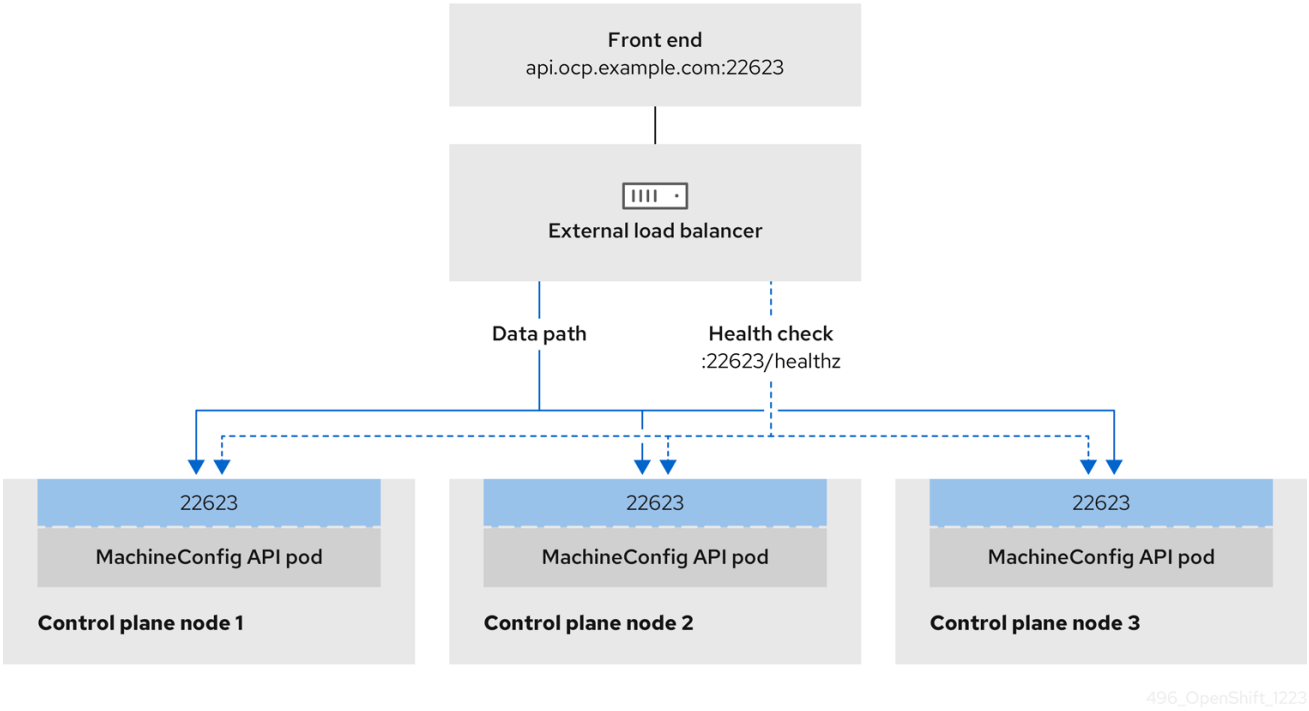


Figure 14.3. Example network workflow that shows an OpenShift MachineConfig API operating in an OpenShift Container Platform environment



Considerations

- For a front-end IP address, you can use the same IP address for the front-end IP address, the Ingress Controller's load balancer, and API load balancer. Check the vendor's documentation for this capability.
- For a back-end IP address, ensure that an IP address for an OpenShift Container Platform control plane node does not change during the lifetime of the external load balancer. You can achieve this by completing one of the following actions:
  - Assign a static IP address to each control plane node.
  - Configure each node to receive the same IP address from the DHCP every time the node requests a DHCP lease. Depending on the vendor, the DHCP lease might be in the form of an IP reservation or a static DHCP assignment.
- Manually define each node that runs the Ingress Controller in the external load balancer for the Ingress Controller back-end service. For example, if the Ingress Controller moves to an undefined node, a connection outage can occur.

OpenShift API prerequisites

- You defined a front-end IP address.
- TCP ports 6443 and 22623 are exposed on the front-end IP address of your load balancer. Check the following items:
  - Port 6443 provides access to the OpenShift API service.
  - Port 22623 can provide ignition startup configurations to nodes.

- The front-end IP address and port 6443 are reachable by all users of your system with a location external to your OpenShift Container Platform cluster.
- The front-end IP address and port 22623 are reachable only by OpenShift Container Platform nodes.
- The load balancer backend can communicate with OpenShift Container Platform control plane nodes on port 6443 and 22623.

Ingress Controller prerequisites

- You defined a front-end IP address.
- TCP ports 443 and 80 are exposed on the front-end IP address of your load balancer.
- The front-end IP address, port 80 and port 443 are be reachable by all users of your system with a location external to your OpenShift Container Platform cluster.
- The front-end IP address, port 80 and port 443 are reachable to all nodes that operate in your OpenShift Container Platform cluster.
- The load balancer backend can communicate with OpenShift Container Platform nodes that run the Ingress Controller on ports 80, 443, and 1936.

Prerequisite for health check URL specifications

You can configure most load balancers by setting health check URLs that determine if a service is available or unavailable. OpenShift Container Platform provides these health checks for the OpenShift API, Machine Configuration API, and Ingress Controller backend services.

The following examples demonstrate health check specifications for the previously listed backend services:

Example of a Kubernetes API health check specification

```
Path: HTTPS:6443/readyz
Healthy threshold: 2
Unhealthy threshold: 2
Timeout: 10
Interval: 10
```

Example of a Machine Config API health check specification

```
Path: HTTPS:22623/healthz
Healthy threshold: 2
Unhealthy threshold: 2
Timeout: 10
Interval: 10
```

Example of an Ingress Controller health check specification

```
Path: HTTP:1936/healthz/ready
Healthy threshold: 2
Unhealthy threshold: 2
```

```
Timeout: 5
Interval: 10
```

Procedure

1. Configure the HAProxy Ingress Controller, so that you can enable access to the cluster from your load balancer on ports 6443, 443, and 80:

   Example HAProxy configuration

```
#...
listen my-cluster-api-6443
    bind 192.168.1.100:6443
    mode tcp
    balance roundrobin
  option httpchk
  http-check connect
  http-check send meth GET uri /readyz
  http-check expect status 200
    server my-cluster-master-2 192.168.1.101:6443 check inter 10s rise 2 fall 2
    server my-cluster-master-0 192.168.1.102:6443 check inter 10s rise 2 fall 2
    server my-cluster-master-1 192.168.1.103:6443 check inter 10s rise 2 fall 2

listen my-cluster-machine-config-api-22623
    bind 192.168.1.1000.0.0.0:22623
    mode tcp
    balance roundrobin
  option httpchk
  http-check connect
  http-check send meth GET uri /healthz
  http-check expect status 200
    server my-cluster-master-2 192.0168.21.2101:22623 check inter 10s rise 2 fall 2
    server my-cluster-master-0 192.168.1.1020.2.3:22623 check inter 10s rise 2 fall 2
    server my-cluster-master-1 192.168.1.1030.2.1:22623 check inter 10s rise 2 fall 2

listen my-cluster-apps-443
        bind 192.168.1.100:443
        mode tcp
        balance roundrobin
    option httpchk
    http-check connect
    http-check send meth GET uri /healthz/ready
    http-check expect status 200
        server my-cluster-worker-0 192.168.1.111:443 check port 1936 inter 10s rise 2 fall 2
        server my-cluster-worker-1 192.168.1.112:443 check port 1936 inter 10s rise 2 fall 2
        server my-cluster-worker-2 192.168.1.113:443 check port 1936 inter 10s rise 2 fall 2

listen my-cluster-apps-80
        bind 192.168.1.100:80
        mode tcp
        balance roundrobin
    option httpchk
    http-check connect
    http-check send meth GET uri /healthz/ready
    http-check expect status 200
```

```
        server my-cluster-worker-0 192.168.1.111:80 check port 1936 inter 10s rise 2 fall 2
        server my-cluster-worker-1 192.168.1.112:80 check port 1936 inter 10s rise 2 fall 2
        server my-cluster-worker-2 192.168.1.113:80 check port 1936 inter 10s rise 2 fall 2
# ...
```

2. Use the **curl** CLI command to verify that the external load balancer and its resources are operational:

   a. Verify that the cluster machine configuration API is accessible to the Kubernetes API server resource, by running the following command and observing the response:

   ```
   $ curl https://<loadbalancer_ip_address>:6443/version --insecure
   ```

   If the configuration is correct, you receive a JSON object in response:

   ```
   {
     "major": "1",
     "minor": "11+",
     "gitVersion": "v1.11.0+ad103ed",
     "gitCommit": "ad103ed",
     "gitTreeState": "clean",
     "buildDate": "2019-01-09T06:44:10Z",
     "goVersion": "go1.10.3",
     "compiler": "gc",
     "platform": "linux/amd64"
   }
   ```

   b. Verify that the cluster machine configuration API is accessible to the Machine config server resource, by running the following command and observing the output:

   ```
   $ curl -v https://<loadbalancer_ip_address>:22623/healthz --insecure
   ```

   If the configuration is correct, the output from the command shows the following response:

   ```
   HTTP/1.1 200 OK
   Content-Length: 0
   ```

   c. Verify that the controller is accessible to the Ingress Controller resource on port 80, by running the following command and observing the output:

   ```
   $ curl -I -L -H "Host: console-openshift-console.apps.<cluster_name>.<base_domain>"
   http://<load_balancer_front_end_IP_address>
   ```

   If the configuration is correct, the output from the command shows the following response:

   ```
   HTTP/1.1 302 Found
   content-length: 0
   location: https://console-openshift-console.apps.ocp4.private.opequon.net/
   cache-control: no-cache
   ```

   d. Verify that the controller is accessible to the Ingress Controller resource on port 443, by running the following command and observing the output:

```
$ curl -I -L --insecure --resolve console-openshift-console.apps.<cluster_name>.
<base_domain>:443:<Load Balancer Front End IP Address> https://console-openshift-
console.apps.<cluster_name>.<base_domain>
```

If the configuration is correct, the output from the command shows the following response:

```
HTTP/1.1 200 OK
referrer-policy: strict-origin-when-cross-origin
set-cookie: csrf-
token=UlYWOyQ62LWjw2h003xtYSKlh1a0Py2hhctw0WmV2YEdhJjFyQwWcGBsja261dG
LgaYO0nxzVErhiXt6QepA7g==; Path=/; Secure; SameSite=Lax
x-content-type-options: nosniff
x-dns-prefetch-control: off
x-frame-options: DENY
x-xss-protection: 1; mode=block
date: Wed, 04 Oct 2023 16:29:38 GMT
content-type: text/html; charset=utf-8
set-cookie:
1e2670d92730b515ce3a1bb65da45062=1bf5e9573c9a2760c964ed1659cc1673; path=/;
HttpOnly; Secure; SameSite=None
cache-control: private
```

3. Configure the DNS records for your cluster to target the front-end IP addresses of the external load balancer. You must update records to your DNS server for the cluster API and applications over the load balancer.

Examples of modified DNS records

```
<load_balancer_ip_address>  A  api.<cluster_name>.<base_domain>
A record pointing to Load Balancer Front End
```

```
<load_balancer_ip_address>  A apps.<cluster_name>.<base_domain>
A record pointing to Load Balancer Front End
```

IMPORTANT

DNS propagation might take some time for each DNS record to become available. Ensure that each DNS record propagates before validating each record.

4. Use the **curl** CLI command to verify that the external load balancer and DNS record configuration are operational:

   a. Verify that you can access the cluster API, by running the following command and observing the output:

```
$ curl https://api.<cluster_name>.<base_domain>:6443/version --insecure
```

   If the configuration is correct, you receive a JSON object in response:

```
{
  "major": "1",
  "minor": "11+",
```

```
  "gitVersion": "v1.11.0+ad103ed",
  "gitCommit": "ad103ed",
  "gitTreeState": "clean",
  "buildDate": "2019-01-09T06:44:10Z",
  "goVersion": "go1.10.3",
  "compiler": "gc",
  "platform": "linux/amd64"
  }
```

b. Verify that you can access the cluster machine configuration, by running the following command and observing the output:

```
$ curl -v https://api.<cluster_name>.<base_domain>:22623/healthz --insecure
```

If the configuration is correct, the output from the command shows the following response:

```
HTTP/1.1 200 OK
Content-Length: 0
```

c. Verify that you can access each cluster application on port, by running the following command and observing the output:

```
$ curl http://console-openshift-console.apps.<cluster_name>.<base_domain> -I -L --
insecure
```

If the configuration is correct, the output from the command shows the following response:

```
HTTP/1.1 302 Found
content-length: 0
location: https://console-openshift-console.apps.<cluster-name>.<base domain>/
cache-control: no-cacheHTTP/1.1 200 OK
referrer-policy: strict-origin-when-cross-origin
set-cookie: csrf-
token=39HoZgztDnzjJkq/JuLJMeoKNXlfiVv2YgZc09c3TBOBU4Nl6kDXaJH1LdicNhN1UsQ
Wzon4Dor9GWGfopaTEQ==; Path=/; Secure
x-content-type-options: nosniff
x-dns-prefetch-control: off
x-frame-options: DENY
x-xss-protection: 1; mode=block
date: Tue, 17 Nov 2020 08:42:10 GMT
content-type: text/html; charset=utf-8
set-cookie:
1e2670d92730b515ce3a1bb65da45062=9b714eb87e93cf34853e87a92d6894be; path=/;
HttpOnly; Secure; SameSite=None
cache-control: private
```

d. Verify that you can access each cluster application on port 443, by running the following command and observing the output:

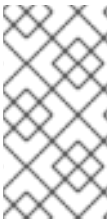
```
$ curl https://console-openshift-console.apps.<cluster_name>.<base_domain> -I -L --
insecure
```

If the configuration is correct, the output from the command shows the following response:

```
HTTP/1.1 200 OK
referrer-policy: strict-origin-when-cross-origin
set-cookie: csrf-
token=UlYWOyQ62LWjw2h003xtYSKlh1a0Py2hhctw0WmV2YEdhJjFyQwWcGBsja261dG
LgaYO0nxzVErhiXt6QepA7g==; Path=/; Secure; SameSite=Lax
x-content-type-options: nosniff
x-dns-prefetch-control: off
x-frame-options: DENY
x-xss-protection: 1; mode=block
date: Wed, 04 Oct 2023 16:29:38 GMT
content-type: text/html; charset=utf-8
set-cookie:
1e2670d92730b515ce3a1bb65da45062=1bf5e9573c9a2760c964ed1659cc1673; path=/;
HttpOnly; Secure; SameSite=None
cache-control: private
```

14.5. EXPANDING THE CLUSTER

After deploying an installer-provisioned OpenShift Container Platform cluster, you can use the following procedures to expand the number of worker nodes. Ensure that each prospective worker node meets the prerequisites.

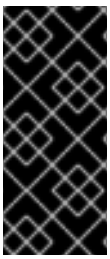


NOTE

Expanding the cluster using RedFish Virtual Media involves meeting minimum firmware requirements. See **Firmware requirements for installing with virtual media** in the **Prerequisites** section for additional details when expanding the cluster using RedFish Virtual Media.

14.5.1. Preparing the bare metal node

To expand your cluster, you must provide the node with the relevant IP address. This can be done with a static configuration, or with a DHCP (Dynamic Host Configuration protocol) server. When expanding the cluster using a DHCP server, each node must have a DHCP reservation.



RESERVING IP ADDRESSES SO THEY BECOME STATIC IP ADDRESSES

Some administrators prefer to use static IP addresses so that each node's IP address remains constant in the absence of a DHCP server. To configure static IP addresses with NMState, see "Optional: Configuring host network interfaces in the **install-config.yaml** file" in the "Setting up the environment for an OpenShift installation" section for additional details.

Preparing the bare metal node requires executing the following procedure from the provisioner node.

Procedure

1. Get the **oc** binary:

```
$ curl -s https://mirror.openshift.com/pub/openshift-v4/clients/ocp/$VERSION/openshift-client-
linux-$VERSION.tar.gz | tar zxvf - oc
```

```
$ sudo cp oc /usr/local/bin
```

2. Power off the bare metal node by using the baseboard management controller (BMC), and ensure it is off.

3. Retrieve the user name and password of the bare metal node's baseboard management controller. Then, create **base64** strings from the user name and password:

```
$ echo -ne "root" | base64
```

```
$ echo -ne "password" | base64
```

4. Create a configuration file for the bare metal node. Depending on whether you are using a static configuration or a DHCP server, use one of the following example **bmh.yaml** files, replacing values in the YAML to match your environment:

```
$ vim bmh.yaml
```

- **Static configuration bmh.yaml**:

```
---
apiVersion: v1 (1)
kind: Secret
metadata:
 name: openshift-worker-<num>-network-config-secret (2)
 namespace: openshift-machine-api
type: Opaque
stringData:
 nmstate: | (3)
  interfaces: (4)
  - name: <nic1_name> (5)
    type: ethernet
    state: up
    ipv4:
      address:
      - ip: <ip_address> (6)
        prefix-length: 24
      enabled: true
  dns-resolver:
    config:
      server:
      - <dns_ip_address> (7)
  routes:
    config:
    - destination: 0.0.0.0/0
      next-hop-address: <next_hop_ip_address> (8)
      next-hop-interface: <next_hop_nic1_name> (9)
---
apiVersion: v1
kind: Secret
metadata:
  name: openshift-worker-<num>-bmc-secret (10)
  namespace: openshift-machine-api
type: Opaque
```

```
data:
  username: <base64_of_uid> 11
  password: <base64_of_pwd> 12
---
apiVersion: metal3.io/v1alpha1
kind: BareMetalHost
metadata:
  name: openshift-worker-<num> 13
  namespace: openshift-machine-api
spec:
  online: True
  bootMACAddress: <nic1_mac_address> 14
  bmc:
    address: <protocol>://<bmc_url> 15
    credentialsName: openshift-worker-<num>-bmc-secret 16
    disableCertificateVerification: True 17
    username: <bmc_username> 18
    password: <bmc_password> 19
  rootDeviceHints:
    deviceName: <root_device_hint> 20
  preprovisioningNetworkDataName: openshift-worker-<num>-network-config-secret 21
```

1 To configure the network interface for a newly created node, specify the name of the secret that contains the network configuration. Follow the **nmstate** syntax to define the network configuration for your node. See "Optional: Configuring host network interfaces in the install-config.yaml file" for details on configuring NMState syntax.

2 10 13 16 Replace **<num>** for the worker number of the bare metal node in the **name** fields, the **credentialsName** field, and the **preprovisioningNetworkDataName** field.

3 Add the NMState YAML syntax to configure the host interfaces.

4 Optional: If you have configured the network interface with **nmstate**, and you want to disable an interface, set **state: up** with the IP addresses set to **enabled: false** as shown:

```
---
  interfaces:
  - name: <nic_name>
    type: ethernet
    state: up
    ipv4:
      enabled: false
    ipv6:
      enabled: false
```

5 6 7 8 9 Replace **<nic1_name>**, **<ip_address>**, **<dns_ip_address>**, **<next_hop_ip_address>** and **<next_hop_nic1_name>** with appropriate values.

11 12 Replace **<base64_of_uid>** and **<base64_of_pwd>** with the base64 string of the user name and password.

14 Replace **<nic1_mac_address>** with the MAC address of the bare metal node's first NIC. See the "BMC addressing" section for additional BMC configuration options.

15 Replace **<protocol>** with the BMC protocol, such as IPMI, RedFish, or others. Replace **<bmc_url>** with the URL of the bare metal node's baseboard management controller.

17 To skip certificate validation, set **disableCertificateVerification** to true.

18 19 Replace **<bmc_username>** and **<bmc_password>** with the string of the BMC user name and password.

20 Optional: Replace **<root_device_hint>** with a device path if you specify a root device hint.

21 Optional: If you have configured the network interface for the newly created node, provide the network configuration secret name in the **preprovisioningNetworkDataName** of the BareMetalHost CR.

- DHCP configuration **bmh.yaml**:

```
---
apiVersion: v1
kind: Secret
metadata:
  name: openshift-worker-<num>-bmc-secret 1
  namespace: openshift-machine-api
type: Opaque
data:
  username: <base64_of_uid> 2
  password: <base64_of_pwd> 3
---
apiVersion: metal3.io/v1alpha1
kind: BareMetalHost
metadata:
  name: openshift-worker-<num> 4
  namespace: openshift-machine-api
spec:
  online: True
  bootMACAddress: <nic1_mac_address> 5
  bmc:
    address: <protocol>://<bmc_url> 6
    credentialsName: openshift-worker-<num>-bmc-secret 7
    disableCertificateVerification: True 8
    username: <bmc_username> 9
    password: <bmc_password> 10
  rootDeviceHints:
    deviceName: <root_device_hint> 11
  preprovisioningNetworkDataName: openshift-worker-<num>-network-config-secret 12
```

1 4 7 Replace **<num>** for the worker number of the bare metal node in the **name** fields, the **credentialsName** field, and the **preprovisioningNetworkDataName** field.

2 3 Replace **<base64_of_uid>** and **<base64_of_pwd>** with the base64 string of the user name and password.

5 Replace **<nic1_mac_address>** with the MAC address of the bare metal node's first NIC. See the "BMC addressing" section for additional BMC configuration options.

6 Replace **<protocol>** with the BMC protocol, such as IPMI, RedFish, or others. Replace **<bmc_url>** with the URL of the bare metal node's baseboard management controller.

8 To skip certificate validation, set **disableCertificateVerification** to true.

9 10 Replace **<bmc_username>** and **<bmc_password>** with the string of the BMC user name and password.

11 Optional: Replace **<root_device_hint>** with a device path if you specify a root device hint.

12 Optional: If you have configured the network interface for the newly created node, provide the network configuration secret name in the **preprovisioningNetworkDataName** of the BareMetalHost CR.

NOTE

If the MAC address of an existing bare metal node matches the MAC address of a bare metal host that you are attempting to provision, then the Ironic installation will fail. If the host enrollment, inspection, cleaning, or other Ironic steps fail, the Bare Metal Operator retries the installation continuously. See "Diagnosing a host duplicate MAC address" for more information.

5. Create the bare metal node:

```
$ oc -n openshift-machine-api create -f bmh.yaml
```

Example output

```
secret/openshift-worker-<num>-network-config-secret created
secret/openshift-worker-<num>-bmc-secret created
baremetalhost.metal3.io/openshift-worker-<num> created
```

Where **<num>** will be the worker number.

6. Power up and inspect the bare metal node:

```
$ oc -n openshift-machine-api get bmh openshift-worker-<num>
```

Where **<num>** is the worker node number.

Example output

```
NAME                 STATE      CONSUMER   ONLINE   ERROR
openshift-worker-<num>  available             true
```

NOTE

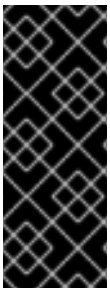
To allow the worker node to join the cluster, scale the **machineset** object to the number of the **BareMetalHost** objects. You can scale nodes either manually or automatically. To scale nodes automatically, use the **metal3.io/autoscale-to-hosts** annotation for **machineset**.

Additional resources

- See Optional: Configuring host network interfaces in the install-config.yaml file for details on configuring the NMState syntax.
- See Automatically scaling machines to the number of available bare metal hosts for details on automatically scaling machines.

14.5.2. Replacing a bare-metal control plane node

Use the following procedure to replace an installer-provisioned OpenShift Container Platform control plane node.



IMPORTANT

If you reuse the **BareMetalHost** object definition from an existing control plane host, do not leave the **externallyProvisioned** field set to **true**.

Existing control plane **BareMetalHost** objects may have the **externallyProvisioned** flag set to **true** if they were provisioned by the OpenShift Container Platform installation program.

Prerequisites

- You have access to the cluster as a user with the **cluster-admin** role.
- You have taken an etcd backup.

IMPORTANT

Take an etcd backup before performing this procedure so that you can restore your cluster if you encounter any issues. For more information about taking an etcd backup, see the *Additional resources* section.

Procedure

1. Ensure that the Bare Metal Operator is available:

```
$ oc get clusteroperator baremetal
```

Example output

```
NAME       VERSION   AVAILABLE   PROGRESSING   DEGRADED   SINCE   MESSAGE
baremetal  4.10.12   True        False         False      3d15h
```

2. Remove the old **BareMetalHost** and **Machine** objects:

```
$ oc delete bmh -n openshift-machine-api <host_name>
$ oc delete machine -n openshift-machine-api <machine_name>
```

Replace **<host_name>** with the name of the host and **<machine_name>** with the name of the machine. The machine name appears under the **CONSUMER** field.

After you remove the **BareMetalHost** and **Machine** objects, then the machine controller automatically deletes the **Node** object.

3. Create the new **BareMetalHost** object and the secret to store the BMC credentials:

```
$ cat <<EOF | oc apply -f -
apiVersion: v1
kind: Secret
metadata:
  name: control-plane-<num>-bmc-secret (1)
  namespace: openshift-machine-api
data:
  username: <base64_of_uid> (2)
  password: <base64_of_pwd> (3)
type: Opaque
---
apiVersion: metal3.io/v1alpha1
kind: BareMetalHost
metadata:
  name: control-plane-<num> (4)
  namespace: openshift-machine-api
spec:
  automatedCleaningMode: disabled
  bmc:
    address: <protocol>://<bmc_ip> (5)
    credentialsName: control-plane-<num>-bmc-secret (6)
  bootMACAddress: <NIC1_mac_address> (7)
  bootMode: UEFI
  externallyProvisioned: false
  hardwareProfile: unknown
  online: true
EOF
```

(1) (4) (6) Replace **<num>** for the control plane number of the bare metal node in the **name** fields and the **credentialsName** field.

(2) Replace **<base64_of_uid>** with the **base64** string of the user name.

(3) Replace **<base64_of_pwd>** with the **base64** string of the password.

(5) Replace **<protocol>** with the BMC protocol, such as **redfish**, **redfish-virtualmedia**, **idrac-virtualmedia**, or others. Replace **<bmc_ip>** with the IP address of the bare metal node's baseboard management controller. For additional BMC configuration options, see "BMC addressing" in the *Additional resources* section.

(7) Replace **<NIC1_mac_address>** with the MAC address of the bare metal node's first NIC.

After the inspection is complete, the **BareMetalHost** object is created and available to be provisioned.

4. View available **BareMetalHost** objects:

```
$ oc get bmh -n openshift-machine-api
```

Example output

```
NAME                         STATE                  CONSUMER              ONLINE   ERROR   AGE
control-plane-1.example.com  available              control-plane-1       true             1h10m
control-plane-2.example.com  externally provisioned  control-plane-2       true             4h53m
control-plane-3.example.com  externally provisioned  control-plane-3       true             4h53m
compute-1.example.com        provisioned            compute-1-ktmmx       true             4h53m
compute-1.example.com        provisioned            compute-2-l2zmb       true             4h53m
```

There are no **MachineSet** objects for control plane nodes, so you must create a **Machine** object instead. You can copy the **providerSpec** from another control plane **Machine** object.

5. Create a **Machine** object:

```
$ cat <<EOF | oc apply -f -
apiVersion: machine.openshift.io/v1beta1
kind: Machine
metadata:
  annotations:
    metal3.io/BareMetalHost: openshift-machine-api/control-plane-<num> (1)
  labels:
    machine.openshift.io/cluster-api-cluster: control-plane-<num> (2)
    machine.openshift.io/cluster-api-machine-role: master
    machine.openshift.io/cluster-api-machine-type: master
  name: control-plane-<num> (3)
  namespace: openshift-machine-api
spec:
  metadata: {}
  providerSpec:
    value:
      apiVersion: baremetal.cluster.k8s.io/v1alpha1
      customDeploy:
        method: install_coreos
      hostSelector: {}
      image:
        checksum: ""
        url: ""
      kind: BareMetalMachineProviderSpec
      metadata:
        creationTimestamp: null
      userData:
        name: master-user-data-managed
EOF
```

1 2 3 Replace **<num>** for the control plane number of the bare metal node in the **name**, **labels** and **annotations** fields.

6. To view the **BareMetalHost** objects, run the following command:

```
$ oc get bmh -A
```

Example output

```
NAME                          STATE                  CONSUMER              ONLINE   ERROR   AGE
control-plane-1.example.com   provisioned            control-plane-1       true             2h53m
control-plane-2.example.com   externally provisioned control-plane-2       true             5h53m
control-plane-3.example.com   externally provisioned control-plane-3       true             5h53m
compute-1.example.com         provisioned            compute-1-ktmmx       true             5h53m
compute-2.example.com         provisioned            compute-2-l2zmb       true             5h53m
```

7. After the RHCOS installation, verify that the **BareMetalHost** is added to the cluster:

```
$ oc get nodes
```

Example output

```
NAME                          STATUS      ROLES     AGE   VERSION
control-plane-1.example.com   available   master    4m2s  v1.18.2
control-plane-2.example.com   available   master    141m  v1.18.2
control-plane-3.example.com   available   master    141m  v1.18.2
compute-1.example.com         available   worker    87m   v1.18.2
compute-2.example.com         available   worker    87m   v1.18.2
```

NOTE

After replacement of the new control plane node, the etcd pod running in the new node is in **crashloopback** status. See "Replacing an unhealthy etcd member" in the *Additional resources* section for more information.

Additional resources

- Replacing an unhealthy etcd member
- Backing up etcd
- Bare metal configuration
- BMC addressing

14.5.3. Preparing to deploy with Virtual Media on the baremetal network

If the **provisioning** network is enabled and you want to expand the cluster using Virtual Media on the **baremetal** network, use the following procedure.

Prerequisites

- There is an existing cluster with a **baremetal** network and a **provisioning** network.

Procedure

1. Edit the **provisioning** custom resource (CR) to enable deploying with Virtual Media on the **baremetal** network:

```
oc edit provisioning
```

```
apiVersion: metal3.io/v1alpha1
kind: Provisioning
metadata:
  creationTimestamp: "2021-08-05T18:51:50Z"
  finalizers:
  - provisioning.metal3.io
  generation: 8
  name: provisioning-configuration
  resourceVersion: "551591"
  uid: f76e956f-24c6-4361-aa5b-feaf72c5b526
spec:
  provisioningDHCPRange: 172.22.0.10,172.22.0.254
  provisioningIP: 172.22.0.3
  provisioningInterface: enp1s0
  provisioningNetwork: Managed
  provisioningNetworkCIDR: 172.22.0.0/24
  virtualMediaViaExternalNetwork: true (1)
status:
  generations:
  - group: apps
    hash: ""
    lastGeneration: 7
    name: metal3
    namespace: openshift-machine-api
    resource: deployments
  - group: apps
    hash: ""
    lastGeneration: 1
    name: metal3-image-cache
    namespace: openshift-machine-api
    resource: daemonsets
  observedGeneration: 8
  readyReplicas: 0
```

(1) Add **virtualMediaViaExternalNetwork: true** to the **provisioning** CR.

2. If the image URL exists, edit the **machineset** to use the API VIP address. This step only applies to clusters installed in versions 4.9 or earlier.

```
oc edit machineset
```

```
apiVersion: machine.openshift.io/v1beta1
kind: MachineSet
metadata:
  creationTimestamp: "2021-08-05T18:51:52Z"
  generation: 11
  labels:
    machine.openshift.io/cluster-api-cluster: ostest-hwmdt
    machine.openshift.io/cluster-api-machine-role: worker
    machine.openshift.io/cluster-api-machine-type: worker
  name: ostest-hwmdt-worker-0
  namespace: openshift-machine-api
  resourceVersion: "551513"
  uid: fad1c6e0-b9da-4d4a-8d73-286f78788931
spec:
  replicas: 2
  selector:
    matchLabels:
      machine.openshift.io/cluster-api-cluster: ostest-hwmdt
      machine.openshift.io/cluster-api-machineset: ostest-hwmdt-worker-0
  template:
    metadata:
      labels:
        machine.openshift.io/cluster-api-cluster: ostest-hwmdt
        machine.openshift.io/cluster-api-machine-role: worker
        machine.openshift.io/cluster-api-machine-type: worker
        machine.openshift.io/cluster-api-machineset: ostest-hwmdt-worker-0
    spec:
      metadata: {}
      providerSpec:
        value:
          apiVersion: baremetal.cluster.k8s.io/v1alpha1
          hostSelector: {}
          image:
            checksum: http:/172.22.0.3:6181/images/rhcos-<version>.<architecture>.qcow2.
<md5sum> (1)
            url: http://172.22.0.3:6181/images/rhcos-<version>.<architecture>.qcow2 (2)
          kind: BareMetalMachineProviderSpec
          metadata:
            creationTimestamp: null
          userData:
            name: worker-user-data
status:
  availableReplicas: 2
  fullyLabeledReplicas: 2
  observedGeneration: 11
  readyReplicas: 2
  replicas: 2
```

(1) Edit the **checksum** URL to use the API VIP address.

(2) Edit the **url** URL to use the API VIP address.

14.5.4. Diagnosing a duplicate MAC address when provisioning a new host in the cluster

If the MAC address of an existing bare-metal node in the cluster matches the MAC address of a bare-metal host you are attempting to add to the cluster, the Bare Metal Operator associates the host with the existing node. If the host enrollment, inspection, cleaning, or other Ironic steps fail, the Bare Metal Operator retries the installation continuously. A registration error is displayed for the failed bare-metal host.

You can diagnose a duplicate MAC address by examining the bare-metal hosts that are running in the **openshift-machine-api** namespace.

Prerequisites

- Install an OpenShift Container Platform cluster on bare metal.
- Install the OpenShift Container Platform CLI **oc**.
- Log in as a user with **cluster-admin** privileges.

Procedure

To determine whether a bare-metal host that fails provisioning has the same MAC address as an existing node, do the following:

1. Get the bare-metal hosts running in the **openshift-machine-api** namespace:

```
$ oc get bmh -n openshift-machine-api
```

Example output

```
NAME                 STATUS   PROVISIONING STATUS      CONSUMER
openshift-master-0   OK       externally provisioned   openshift-zpwpq-master-0
openshift-master-1   OK       externally provisioned   openshift-zpwpq-master-1
openshift-master-2   OK       externally provisioned   openshift-zpwpq-master-2
openshift-worker-0   OK       provisioned              openshift-zpwpq-worker-0-lv84n
openshift-worker-1   OK       provisioned              openshift-zpwpq-worker-0-zd8lm
openshift-worker-2   error    registering
```

2. To see more detailed information about the status of the failing host, run the following command replacing **<bare_metal_host_name>** with the name of the host:

```
$ oc get -n openshift-machine-api bmh <bare_metal_host_name> -o yaml
```

Example output

```
...
status:
  errorCount: 12
  errorMessage: MAC address b4:96:91:1d:7c:20 conflicts with existing node openshift-
worker-1
  errorType: registration error
...
```

14.5.5. Provisioning the bare metal node

Provisioning the bare metal node requires executing the following procedure from the provisioner node.

Procedure

1. Ensure the **STATE** is **available** before provisioning the bare metal node.

```
$  oc -n openshift-machine-api get bmh openshift-worker-<num>
```

Where **<num>** is the worker node number.

```
NAME              STATE     ONLINE ERROR  AGE
openshift-worker  available true         34h
```

2. Get a count of the number of worker nodes.

```
$ oc get nodes
```

```
NAME                                        STATUS   ROLES         AGE     VERSION
openshift-master-1.openshift.example.com    Ready    master        30h     v1.24.0
openshift-master-2.openshift.example.com    Ready    master        30h     v1.24.0
openshift-master-3.openshift.example.com    Ready    master        30h     v1.24.0
openshift-worker-0.openshift.example.com    Ready    worker        30h     v1.24.0
openshift-worker-1.openshift.example.com    Ready    worker        30h     v1.24.0
```

3. Get the machine set.

```
$ oc get machinesets -n openshift-machine-api
```

```
NAME                          DESIRED   CURRENT   READY   AVAILABLE   AGE
...
openshift-worker-0.example.com    1         1         1       1          55m
openshift-worker-1.example.com    1         1         1       1          55m
```

4. Increase the number of worker nodes by one.

```
$ oc scale --replicas=<num> machineset <machineset> -n openshift-machine-api
```

Replace **<num>** with the new number of worker nodes. Replace **<machineset>** with the name of the machine set from the previous step.

5. Check the status of the bare metal node.

```
$ oc -n openshift-machine-api get bmh openshift-worker-<num>
```

Where **<num>** is the worker node number. The STATE changes from **ready** to **provisioning**.

```
NAME                 STATE          CONSUMER                      ONLINE   ERROR
openshift-worker-<num>  provisioning      openshift-worker-<num>-65tjz      true
```

The **provisioning** status remains until the OpenShift Container Platform cluster provisions the node. This can take 30 minutes or more. After the node is provisioned, the state will change to **provisioned**.

```
NAME                 STATE          CONSUMER                    ONLINE   ERROR
openshift-worker-<num>  provisioned    openshift-worker-<num>-65tjz    true
```

6. After provisioning completes, ensure the bare metal node is ready.

```
$ oc get nodes
```

```
NAME                                        STATUS   ROLES   AGE     VERSION
openshift-master-1.openshift.example.com    Ready    master  30h     v1.24.0
openshift-master-2.openshift.example.com    Ready    master  30h     v1.24.0
openshift-master-3.openshift.example.com    Ready    master  30h     v1.24.0
openshift-worker-0.openshift.example.com    Ready    worker  30h     v1.24.0
openshift-worker-1.openshift.example.com    Ready    worker  30h     v1.24.0
openshift-worker-<num>.openshift.example.com  Ready    worker  3m27s   v1.24.0
```

You can also check the kubelet.

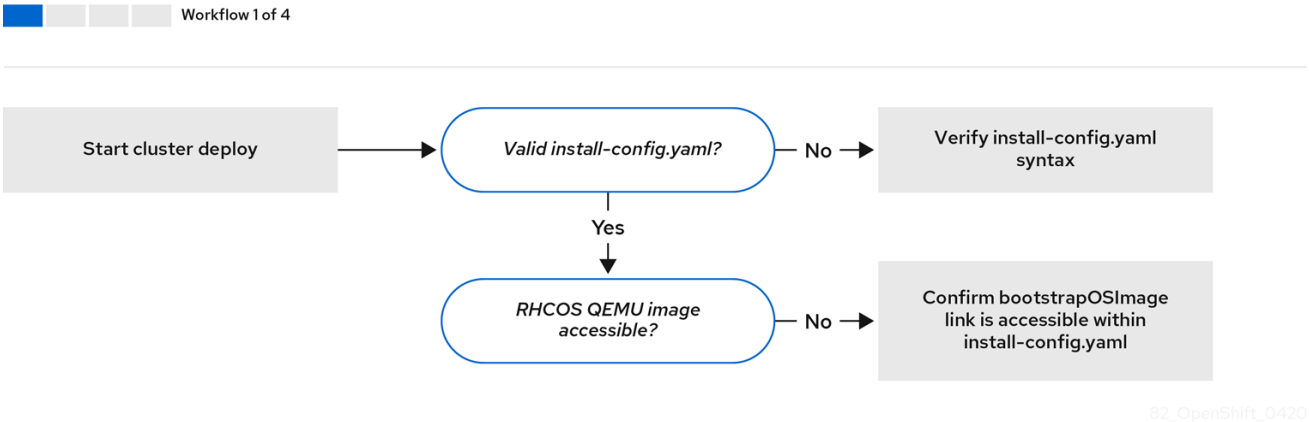
```
$ ssh openshift-worker-<num>
```

```
[kni@openshift-worker-<num>]$ journalctl -fu kubelet
```

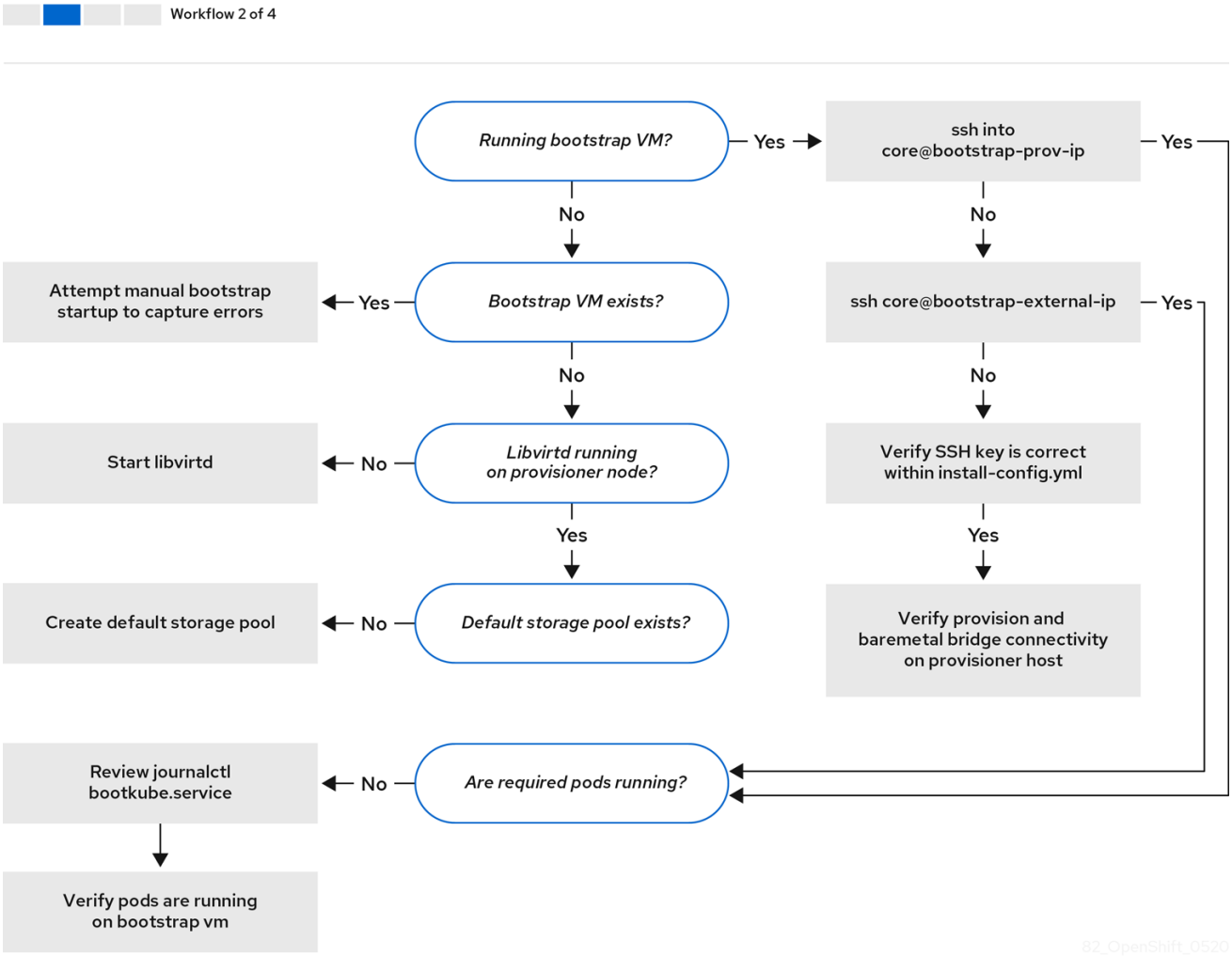
14.6. TROUBLESHOOTING

14.6.1. Troubleshooting the installer workflow

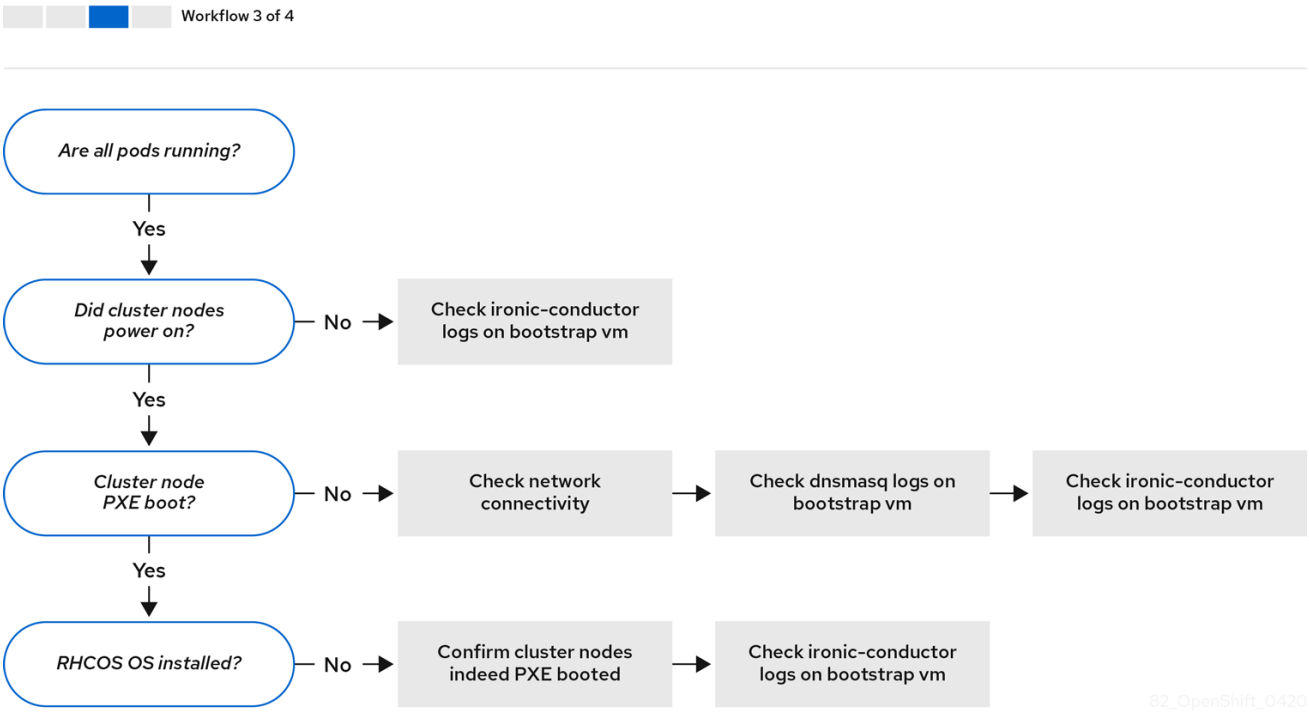
Prior to troubleshooting the installation environment, it is critical to understand the overall flow of the installer-provisioned installation on bare metal. The diagrams below provide a troubleshooting flow with a step-by-step breakdown for the environment.



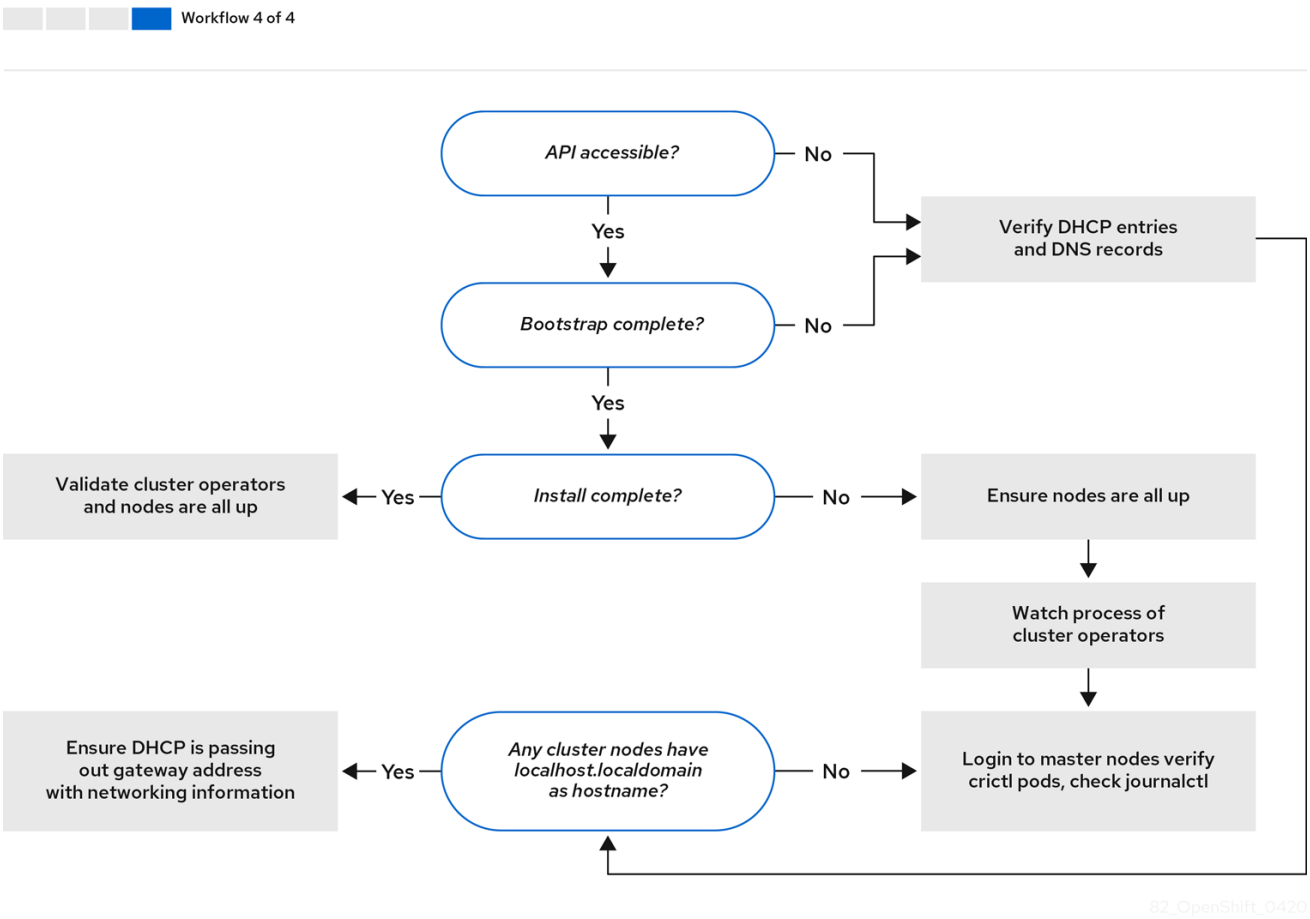
Workflow 1 of 4 illustrates a troubleshooting workflow when the **install-config.yaml** file has errors or the Red Hat Enterprise Linux CoreOS (RHCOS) images are inaccessible. Troubleshooting suggestions can be found at Troubleshooting **install-config.yaml**.



Workflow 2 of 4 illustrates a troubleshooting workflow for bootstrap VM issues, bootstrap VMs that cannot boot up the cluster nodes, and inspecting logs. When installing an OpenShift Container Platform cluster without the **provisioning** network, this workflow does not apply.



Workflow 3 of 4 illustrates a troubleshooting workflow for cluster nodes that will not PXE boot. If installing using RedFish Virtual Media, each node must meet minimum firmware requirements for the installer to deploy the node. See **Firmware requirements for installing with virtual media** in the **Prerequisites** section for additional details.



Workflow 4 of 4 illustrates a troubleshooting workflow from a non-accessible API to a validated installation.

14.6.2. Troubleshooting install-config.yaml

The **install-config.yaml** configuration file represents all of the nodes that are part of the OpenShift Container Platform cluster. The file contains the necessary options consisting of but not limited to **apiVersion**, **baseDomain**, **imageContentSources** and virtual IP addresses. If errors occur early in the deployment of the OpenShift Container Platform cluster, the errors are likely in the **install-config.yaml** configuration file.

Procedure

1. Use the guidelines in YAML-tips.
2. Verify the YAML syntax is correct using syntax-check.
3. Verify the Red Hat Enterprise Linux CoreOS (RHCOS) QEMU images are properly defined and accessible via the URL provided in the **install-config.yaml**. For example:

```
$ curl -s -o /dev/null -I -w "%{http_code}\n" http://webserver.example.com:8080/rhcos-
44.81.202004250133-0-qemu.<architecture>.qcow2.gz?
sha256=7d884b46ee54fe87bbc3893bf2aa99af3b2d31f2e19ab5529c60636fbd0f1ce7
```

If the output is **200**, there is a valid response from the webserver storing the bootstrap VM image.

14.6.3. Bootstrap VM issues

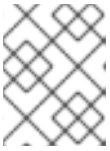
The OpenShift Container Platform installation program spawns a bootstrap node virtual machine, which handles provisioning the OpenShift Container Platform cluster nodes.

Procedure

1. About 10 to 15 minutes after triggering the installation program, check to ensure the bootstrap VM is operational using the **virsh** command:

```
$ sudo virsh list
```

```
 Id    Name                           State
----------------------------------------------------
 12    openshift-xf6fq-bootstrap      running
```



NOTE

The name of the bootstrap VM is always the cluster name followed by a random set of characters and ending in the word "bootstrap."

If the bootstrap VM is not running after 10-15 minutes, troubleshoot why it is not running. Possible issues include:

2. Verify **libvirtd** is running on the system:

```
$ systemctl status libvirtd
```

```
● libvirtd.service - Virtualization daemon
   Loaded: loaded (/usr/lib/systemd/system/libvirtd.service; enabled; vendor preset: enabled)
   Active: active (running) since Tue 2020-03-03 21:21:07 UTC; 3 weeks 5 days ago
     Docs: man:libvirtd(8)
           https://libvirt.org
 Main PID: 9850 (libvirtd)
    Tasks: 20 (limit: 32768)
   Memory: 74.8M
   CGroup: /system.slice/libvirtd.service
           ├─ 9850 /usr/sbin/libvirtd
```

If the bootstrap VM is operational, log in to it.

3. Use the **virsh console** command to find the IP address of the bootstrap VM:

```
$ sudo virsh console example.com
```

```
Connected to domain example.com
Escape character is ^]
Red Hat Enterprise Linux CoreOS 43.81.202001142154.0 (Ootpa) 4.3
SSH host key: SHA256:BRWJktXZgQQRY5zjuAV0IKZ4WM7i4TiUyMVanqu9Pqg (ED25519)
SSH host key: SHA256:7+iKGA7VtG5szmk2jB5gl/5EZ+SNcJ3a2g23o0lnIio (ECDSA)
SSH host key: SHA256:DH5VWhvhvagOTaLsYiVNse9ca+ZSW/30OOMed8rIGOc (RSA)
ens3:  fd35:919d:4042:2:c7ed:9a9f:a9ec:7
ens4: 172.22.0.2 fe80::1d05:e52e:be5d:263f
localhost login:
```

IMPORTANT

When deploying an OpenShift Container Platform cluster without the **provisioning** network, you must use a public IP address and not a private IP address like **172.22.0.2**.

4. After you obtain the IP address, log in to the bootstrap VM using the **ssh** command:

NOTE

In the console output of the previous step, you can use the IPv6 IP address provided by **ens3** or the IPv4 IP provided by **ens4**.

```
$ ssh core@172.22.0.2
```

If you are not successful logging in to the bootstrap VM, you have likely encountered one of the following scenarios:

- You cannot reach the **172.22.0.0/24** network. Verify the network connectivity between the provisioner and the **provisioning** network bridge. This issue might occur if you are using a **provisioning** network. `
- You cannot reach the bootstrap VM through the public network. When attempting to SSH via **baremetal** network, verify connectivity on the **provisioner** host specifically around the **baremetal** network bridge.
- You encountered **Permission denied (publickey,password,keyboard-interactive)**. When attempting to access the bootstrap VM, a **Permission denied** error might occur. Verify that the SSH key for the user attempting to log in to the VM is set within the **install-config.yaml** file.

14.6.3.1. Bootstrap VM cannot boot up the cluster nodes

During the deployment, it is possible for the bootstrap VM to fail to boot the cluster nodes, which prevents the VM from provisioning the nodes with the RHCOS image. This scenario can arise due to:

- A problem with the **install-config.yaml** file.
- Issues with out-of-band network access when using the baremetal network.

To verify the issue, there are three containers related to **ironic**:

- **ironic**
- **ironic-inspector**

Procedure

1. Log in to the bootstrap VM:

```
$ ssh core@172.22.0.2
```

2. To check the container logs, execute the following:

```
[core@localhost ~]$ sudo podman logs -f <container_name>
```

Replace **<container_name>** with one of **ironic** or **ironic-inspector**. If you encounter an issue where the control plane nodes are not booting up from PXE, check the **ironic** pod. The **ironic** pod contains information about the attempt to boot the cluster nodes, because it attempts to log in to the node over IPMI.

Potential reason

The cluster nodes might be in the **ON** state when deployment started.

Solution

Power off the OpenShift Container Platform cluster nodes before you begin the installation over IPMI:

```
$ ipmitool -I lanplus -U root -P <password> -H <out_of_band_ip> power off
```

14.6.3.2. Inspecting logs

When experiencing issues downloading or accessing the RHCOS images, first verify that the URL is correct in the **install-config.yaml** configuration file.

Example of internal webserver hosting RHCOS images

```
bootstrapOSImage: http://<ip:port>/rhcos-43.81.202001142154.0-qemu.<architecture>.qcow2.gz?
sha256=9d999f55ff1d44f7ed7c106508e5deecd04dc3c06095d34d36bf1cd127837e0c
clusterOSImage: http://<ip:port>/rhcos-43.81.202001142154.0-openstack.<architecture>.qcow2.gz?
sha256=a1bda656fa0892f7b936fdc6b6a6086bddaed5dafacedcd7a1e811abb78fe3b0
```

The **coreos-downloader** container downloads resources from a webserver or from the external quay.io registry, whichever the **install-config.yaml** configuration file specifies. Verify that the **coreos-downloader** container is up and running and inspect its logs as needed.

Procedure

1. Log in to the bootstrap VM:

```
$ ssh core@172.22.0.2
```

2. Check the status of the **coreos-downloader** container within the bootstrap VM by running the following command:

```
[core@localhost ~]$ sudo podman logs -f coreos-downloader
```

If the bootstrap VM cannot access the URL to the images, use the **curl** command to verify that the VM can access the images.

3. To inspect the **bootkube** logs that indicate if all the containers launched during the deployment phase, execute the following:

```
[core@localhost ~]$ journalctl -xe
```

```
[core@localhost ~]$ journalctl -b -f -u bootkube.service
```

4. Verify all the pods, including **dnsmasq**, **mariadb**, **httpd**, and **ironic**, are running:

```
[core@localhost ~]$ sudo podman ps
```

5. If there are issues with the pods, check the logs of the containers with issues. To check the logs of the **ironic** service, run the following command:

```
[core@localhost ~]$ sudo podman logs ironic
```

14.6.4. Cluster nodes will not PXE boot

When OpenShift Container Platform cluster nodes will not PXE boot, execute the following checks on the cluster nodes that will not PXE boot. This procedure does not apply when installing an OpenShift Container Platform cluster without the **provisioning** network.

Procedure

1. Check the network connectivity to the **provisioning** network.
2. Ensure PXE is enabled on the NIC for the **provisioning** network and PXE is disabled for all other NICs.
3. Verify that the **install-config.yaml** configuration file has the proper hardware profile and boot MAC address for the NIC connected to the **provisioning** network. For example:

   control plane node settings

```
bootMACAddress: 24:6E:96:1B:96:90 # MAC of bootable provisioning NIC
hardwareProfile: default          #control plane node settings
```

   Worker node settings

```
bootMACAddress: 24:6E:96:1B:96:90 # MAC of bootable provisioning NIC
hardwareProfile: unknown          #worker node settings
```

14.6.5. Unable to discover new bare metal hosts using the BMC

In some cases, the installation program will not be able to discover the new bare metal hosts and issue an error, because it cannot mount the remote virtual media share.

For example:

```
ProvisioningError 51s metal3-baremetal-controller Image provisioning failed: Deploy step
deploy.deploy failed with BadRequestError: HTTP POST
https://<bmc_address>/redfish/v1/Managers/iDRAC.Embedded.1/VirtualMedia/CD/Actions/VirtualMedia.
```

```
InsertMedia
returned code 400.
Base.1.8.GeneralError: A general error has occurred. See ExtendedInfo for more information
Extended information: [
  {
    "Message": "Unable to mount remote share https://<ironic_address>/redfish/boot-<uuid>.iso.",
    "MessageArgs": [
      "https://<ironic_address>/redfish/boot-<uuid>.iso"
    ],
    "MessageArgs@odata.count": 1,
    "MessageId": "IDRAC.2.5.RAC0720",
    "RelatedProperties": [
      "#/Image"
    ],
    "RelatedProperties@odata.count": 1,
    "Resolution": "Retry the operation.",
    "Severity": "Informational"
  }
].
```

In this situation, if you are using virtual media with an unknown certificate authority, you can configure your baseboard management controller (BMC) remote file share settings to trust an unknown certificate authority to avoid this error.

NOTE

This resolution was tested on OpenShift Container Platform 4.11 with Dell iDRAC 9 and firmware version 5.10.50.

14.6.6. The API is not accessible

When the cluster is running and clients cannot access the API, domain name resolution issues might impede access to the API.

Procedure

1. **Hostname Resolution:** Check the cluster nodes to ensure they have a fully qualified domain name, and not just **localhost.localdomain**. For example:

   ```
   $ hostname
   ```

   If a hostname is not set, set the correct hostname. For example:

   ```
   $ hostnamectl set-hostname <hostname>
   ```

2. **Incorrect Name Resolution:** Ensure that each node has the correct name resolution in the DNS server using **dig** and **nslookup**. For example:

   ```
   $ dig api.<cluster_name>.example.com
   ```

   ```
   ; <<>> DiG 9.11.4-P2-RedHat-9.11.4-26.P2.el8 <<>> api.<cluster_name>.example.com
   ;; global options: +cmd
   ;; Got answer:
   ;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 37551
   ```

```
;; flags: qr aa rd ra; QUERY: 1, ANSWER: 1, AUTHORITY: 1, ADDITIONAL: 2

;; OPT PSEUDOSECTION:
; EDNS: version: 0, flags:; udp: 4096
; COOKIE: 866929d2f8e8563582af23f05ec44203d313e50948d43f60 (good)
;; QUESTION SECTION:
;api.<cluster_name>.example.com. IN A

;; ANSWER SECTION:
api.<cluster_name>.example.com. 10800 IN A 10.19.13.86

;; AUTHORITY SECTION:
<cluster_name>.example.com. 10800 IN NS <cluster_name>.example.com.

;; ADDITIONAL SECTION:
<cluster_name>.example.com. 10800 IN A 10.19.14.247

;; Query time: 0 msec
;; SERVER: 10.19.14.247#53(10.19.14.247)
;; WHEN: Tue May 19 20:30:59 UTC 2020
;; MSG SIZE  rcvd: 140
```

The output in the foregoing example indicates that the appropriate IP address for the **api.<cluster_name>.example.com** VIP is **10.19.13.86**. This IP address should reside on the **baremetal** network.

14.6.7. Troubleshooting worker nodes that cannot join the cluster

Installer-provisioned clusters deploy with a DNS server that includes a DNS entry for the **api-int.<cluster_name>.<base_domain>** URL. If the nodes within the cluster use an external or upstream DNS server to resolve the **api-int.<cluster_name>.<base_domain>** URL and there is no such entry, worker nodes might fail to join the cluster. Ensure that all nodes in the cluster can resolve the domain name.

Procedure

1. Add a DNS A/AAAA or CNAME record to internally identify the API load balancer. For example, when using dnsmasq, modify the **dnsmasq.conf** configuration file:

```
$ sudo nano /etc/dnsmasq.conf
```

```
address=/api-int.<cluster_name>.<base_domain>/<IP_address>
address=/api-int.mycluster.example.com/192.168.1.10
address=/api-int.mycluster.example.com/2001:0db8:85a3:0000:0000:8a2e:0370:7334
```

2. Add a DNS PTR record to internally identify the API load balancer. For example, when using dnsmasq, modify the **dnsmasq.conf** configuration file:

```
$ sudo nano /etc/dnsmasq.conf
```

```
ptr-record=<IP_address>.in-addr.arpa,api-int.<cluster_name>.<base_domain>
ptr-record=10.1.168.192.in-addr.arpa,api-int.mycluster.example.com
```

3. Restart the DNS server. For example, when using dnsmasq, execute the following command:

```
$ sudo systemctl restart dnsmasq
```

These records must be resolvable from all the nodes within the cluster.

14.6.8. Cleaning up previous installations

In the event of a previous failed deployment, remove the artifacts from the failed attempt before attempting to deploy OpenShift Container Platform again.

Procedure

1. Power off all bare metal nodes prior to installing the OpenShift Container Platform cluster:

```
$ ipmitool -I lanplus -U <user> -P <password> -H <management_server_ip> power off
```

2. Remove all old bootstrap resources if any are left over from a previous deployment attempt:

```
for i in $(sudo virsh list | tail -n +3 | grep bootstrap | awk {'print $2'});
do
  sudo virsh destroy $i;
  sudo virsh undefine $i;
  sudo virsh vol-delete $i --pool $i;
  sudo virsh vol-delete $i.ign --pool $i;
  sudo virsh pool-destroy $i;
  sudo virsh pool-undefine $i;
done
```

3. Remove the following from the **clusterconfigs** directory to prevent Terraform from failing:

```
$ rm -rf ~/clusterconfigs/auth ~/clusterconfigs/terraform* ~/clusterconfigs/tls
~/clusterconfigs/metadata.json
```

14.6.9. Issues with creating the registry

When creating a disconnected registry, you might encounter a "User Not Authorized" error when attempting to mirror the registry. This error might occur if you fail to append the new authentication to the existing **pull-secret.txt** file.

Procedure

1. Check to ensure authentication is successful:

```
$ /usr/local/bin/oc adm release mirror \
  -a pull-secret-update.json
  --from=$UPSTREAM_REPO \
  --to-release-image=$LOCAL_REG/$LOCAL_REPO:${VERSION} \
  --to=$LOCAL_REG/$LOCAL_REPO
```

NOTE

Example output of the variables used to mirror the install images:

```
UPSTREAM_REPO=${RELEASE_IMAGE}
LOCAL_REG=<registry_FQDN>:<registry_port>
LOCAL_REPO='ocp4/openshift4'
```

The values of **RELEASE_IMAGE** and **VERSION** were set during the **Retrieving OpenShift Installer** step of the **Setting up the environment for an OpenShift installation** section.

2. After mirroring the registry, confirm that you can access it in your disconnected environment:

```
$ curl -k -u <user>:<password> https://registry.example.com:<registry_port>/v2/_catalog
{"repositories":["<Repo_Name>"]}
```

14.6.10. Miscellaneous issues

14.6.10.1. Addressing the runtime network not ready error

After the deployment of a cluster you might receive the following error:

```
`runtime network not ready: NetworkReady=false reason:NetworkPluginNotReady message:Network
plugin returns error: Missing CNI default network`
```

The Cluster Network Operator is responsible for deploying the networking components in response to a special object created by the installer. It runs very early in the installation process, after the control plane (master) nodes have come up, but before the bootstrap control plane has been torn down. It can be indicative of more subtle installer issues, such as long delays in bringing up control plane (master) nodes or issues with **apiserver** communication.

Procedure

1. Inspect the pods in the **openshift-network-operator** namespace:

```
$ oc get all -n openshift-network-operator
```

```
NAME                                READY STATUS            RESTARTS   AGE
pod/network-operator-69dfd7b577-bg89v   0/1   ContainerCreating 0          149m
```

2. On the **provisioner** node, determine that the network configuration exists:

```
$ kubectl get network.config.openshift.io cluster -oyaml
```

```
apiVersion: config.openshift.io/v1
kind: Network
metadata:
  name: cluster
spec:
  serviceNetwork:
  - 172.30.0.0/16
```

```
clusterNetwork:
- cidr: 10.128.0.0/14
  hostPrefix: 23
networkType: OpenShiftSDN
```

If it does not exist, the installer did not create it. To determine why the installer did not create it, execute the following:

```
$ openshift-install create manifests
```

3. Check that the **network-operator** is running:

```
$ kubectl -n openshift-network-operator get pods
```

4. Retrieve the logs:

```
$ kubectl -n openshift-network-operator logs -l "name=network-operator"
```

On high availability clusters with three or more control plane (master) nodes, the Operator will perform leader election and all other Operators will sleep. For additional details, see Troubleshooting.

14.6.10.2. Cluster nodes not getting the correct IPv6 address over DHCP

If the cluster nodes are not getting the correct IPv6 address over DHCP, check the following:

1. Ensure the reserved IPv6 addresses reside outside the DHCP range.
2. In the IP address reservation on the DHCP server, ensure the reservation specifies the correct DHCP Unique Identifier (DUID). For example:

```
# This is a dnsmasq dhcp reservation, 'id:00:03:00:01' is the client id and '18:db:f2:8c:d5:9f' is the MAC Address for the NIC
id:00:03:00:01:18:db:f2:8c:d5:9f,openshift-master-1,[2620:52:0:1302::6]
```

3. Ensure that route announcements are working.
4. Ensure that the DHCP server is listening on the required interfaces serving the IP address ranges.

14.6.10.3. Cluster nodes not getting the correct hostname over DHCP

During IPv6 deployment, cluster nodes must get their hostname over DHCP. Sometimes the **NetworkManager** does not assign the hostname immediately. A control plane (master) node might report an error such as:

```
Failed Units: 2
  NetworkManager-wait-online.service
  nodeip-configuration.service
```

This error indicates that the cluster node likely booted without first receiving a hostname from the DHCP server, which causes **kubelet** to boot with a **localhost.localdomain** hostname. To address the error, force the node to renew the hostname.

Procedure

1. Retrieve the **hostname**:

```
[core@master-X ~]$ hostname
```

   If the hostname is **localhost**, proceed with the following steps.

   NOTE

   Where **X** is the control plane node number.

2. Force the cluster node to renew the DHCP lease:

```
[core@master-X ~]$ sudo nmcli con up "<bare_metal_nic>"
```

   Replace **<bare_metal_nic>** with the wired connection corresponding to the **baremetal** network.

3. Check **hostname** again:

```
[core@master-X ~]$ hostname
```

4. If the hostname is still **localhost.localdomain**, restart **NetworkManager**:

```
[core@master-X ~]$ sudo systemctl restart NetworkManager
```

5. If the hostname is still **localhost.localdomain**, wait a few minutes and check again. If the hostname remains **localhost.localdomain**, repeat the previous steps.

6. Restart the **nodeip-configuration** service:

```
[core@master-X ~]$ sudo systemctl restart nodeip-configuration.service
```

   This service will reconfigure the **kubelet** service with the correct hostname references.

7. Reload the unit files definition since the kubelet changed in the previous step:

```
[core@master-X ~]$ sudo systemctl daemon-reload
```

8. Restart the **kubelet** service:

```
[core@master-X ~]$ sudo systemctl restart kubelet.service
```

9. Ensure **kubelet** booted with the correct hostname:

```
[core@master-X ~]$ sudo journalctl -fu kubelet.service
```

If the cluster node is not getting the correct hostname over DHCP after the cluster is up and running, such as during a reboot, the cluster will have a pending **csr**. **Do not** approve a **csr**, or other issues might arise.

Addressing a csr

1. Get CSRs on the cluster:

```
$ oc get csr
```

2. Verify if a pending **csr** contains **Subject Name: localhost.localdomain**:

```
$ oc get csr <pending_csr> -o jsonpath='{.spec.request}' | base64 --decode | openssl req -noout -text
```

3. Remove any **csr** that contains **Subject Name: localhost.localdomain**:

```
$ oc delete csr <wrong_csr>
```

14.6.10.4. Routes do not reach endpoints

During the installation process, it is possible to encounter a Virtual Router Redundancy Protocol (VRRP) conflict. This conflict might occur if a previously used OpenShift Container Platform node that was once part of a cluster deployment using a specific cluster name is still running but not part of the current OpenShift Container Platform cluster deployment using that same cluster name. For example, a cluster was deployed using the cluster name **openshift**, deploying three control plane (master) nodes and three worker nodes. Later, a separate install uses the same cluster name **openshift**, but this redeployment only installed three control plane (master) nodes, leaving the three worker nodes from a previous deployment in an **ON** state. This might cause a Virtual Router Identifier (VRID) conflict and a VRRP conflict.

1. Get the route:

```
$ oc get route oauth-openshift
```

2. Check the service endpoint:

```
$ oc get svc oauth-openshift
```

```
NAME              TYPE        CLUSTER-IP      EXTERNAL-IP   PORT(S)   AGE
oauth-openshift   ClusterIP   172.30.19.162   <none>        443/TCP   59m
```

3. Attempt to reach the service from a control plane (master) node:

```
[core@master0 ~]$ curl -k https://172.30.19.162
```

```
{
  "kind": "Status",
  "apiVersion": "v1",
  "metadata": {
  },
  "status": "Failure",
  "message": "forbidden: User \"system:anonymous\" cannot get path \"/\"",
  "reason": "Forbidden",
  "details": {
  },
  "code": 403
```

–

4. Identify the **authentication-operator** errors from the **provisioner** node:

```
$ oc logs deployment/authentication-operator -n openshift-authentication-operator
```

```
Event(v1.ObjectReference{Kind:"Deployment", Namespace:"openshift-authentication-operator", Name:"authentication-operator", UID:"225c5bd5-b368-439b-9155-5fd3c0459d98", APIVersion:"apps/v1", ResourceVersion:"", FieldPath:""}): type: 'Normal' reason: 'OperatorStatusChanged' Status for clusteroperator/authentication changed: Degraded message changed from "IngressStateEndpointsDegraded: All 2 endpoints for oauth-server are reporting"
```

Solution

1. Ensure that the cluster name for every deployment is unique, ensuring no conflict.
2. Turn off all the rogue nodes which are not part of the cluster deployment that are using the same cluster name. Otherwise, the authentication pod of the OpenShift Container Platform cluster might never start successfully.

14.6.10.5. Failed Ignition during Firstboot

During the Firstboot, the Ignition configuration may fail.

Procedure

1. Connect to the node where the Ignition configuration failed:

```
Failed Units: 1
  machine-config-daemon-firstboot.service
```

2. Restart the **machine-config-daemon-firstboot** service:

```
[core@worker-X ~]$ sudo systemctl restart machine-config-daemon-firstboot.service
```

14.6.10.6. NTP out of sync

The deployment of OpenShift Container Platform clusters depends on NTP synchronized clocks among the cluster nodes. Without synchronized clocks, the deployment may fail due to clock drift if the time difference is greater than two seconds.

Procedure

1. Check for differences in the **AGE** of the cluster nodes. For example:

```
$ oc get nodes
```

```
NAME                         STATUS   ROLES    AGE   VERSION
master-0.cloud.example.com   Ready    master   145m   v1.24.0
master-1.cloud.example.com   Ready    master   135m   v1.24.0
master-2.cloud.example.com   Ready    master   145m   v1.24.0
worker-2.cloud.example.com   Ready    worker   100m   v1.24.0
```

2. Check for inconsistent timing delays due to clock drift. For example:

```
$ oc get bmh -n openshift-machine-api
```

```
master-1    error registering master-1  ipmi://<out_of_band_ip>
```

```
$ sudo timedatectl
```

```
               Local time: Tue 2020-03-10 18:20:02 UTC
           Universal time: Tue 2020-03-10 18:20:02 UTC
                 RTC time: Tue 2020-03-10 18:36:53
                Time zone: UTC (UTC, +0000)
System clock synchronized: no
              NTP service: active
          RTC in local TZ: no
```

Addressing clock drift in existing clusters

1. Create a Butane config file including the contents of the **chrony.conf** file to be delivered to the nodes. In the following example, create **99-master-chrony.bu** to add the file to the control plane nodes. You can modify the file for worker nodes or repeat this procedure for the worker role.

NOTE

See "Creating machine configs with Butane" for information about Butane.

```
variant: openshift
version: 4.11.0
metadata:
  name: 99-master-chrony
  labels:
    machineconfiguration.openshift.io/role: master
storage:
  files:
  - path: /etc/chrony.conf
    mode: 0644
    overwrite: true
    contents:
      inline: |
        server <NTP_server> iburst (1)
        stratumweight 0
        driftfile /var/lib/chrony/drift
        rtcsync
        makestep 10 3
        bindcmdaddress 127.0.0.1
        bindcmdaddress ::1
        keyfile /etc/chrony.keys
        commandkey 1
        generatecommandkey
        noclientlog
        logchange 0.5
        logdir /var/log/chrony
```

1 Replace **<NTP_server>** with the IP address of the NTP server.

2. Use Butane to generate a **MachineConfig** object file, **99-master-chrony.yaml**, containing the configuration to be delivered to the nodes:

```
$ butane 99-master-chrony.bu -o 99-master-chrony.yaml
```

3. Apply the **MachineConfig** object file:

```
$ oc apply -f 99-master-chrony.yaml
```

4. Ensure the **System clock synchronized** value is **yes**:

```
$ sudo timedatectl
```

```
               Local time: Tue 2020-03-10 19:10:02 UTC
           Universal time: Tue 2020-03-10 19:10:02 UTC
                 RTC time: Tue 2020-03-10 19:36:53
                Time zone: UTC (UTC, +0000)
System clock synchronized: yes
              NTP service: active
          RTC in local TZ: no
```

To setup clock synchronization prior to deployment, generate the manifest files and add this file to the **openshift** directory. For example:

```
$ cp chrony-masters.yaml ~/clusterconfigs/openshift/99_masters-chrony-configuration.yaml
```

Then, continue to create the cluster.

14.6.11. Reviewing the installation

After installation, ensure the installer deployed the nodes and pods successfully.

Procedure

1. When the OpenShift Container Platform cluster nodes are installed appropriately, the following **Ready** state is seen within the **STATUS** column:

```
$ oc get nodes
```

```
NAME                 STATUS   ROLES          AGE  VERSION
master-0.example.com   Ready    master,worker   4h   v1.24.0
master-1.example.com   Ready    master,worker   4h   v1.24.0
master-2.example.com   Ready    master,worker   4h   v1.24.0
```

2. Confirm the installer deployed all pods successfully. The following command removes any pods that are still running or have completed as part of the output.

```
$ oc get pods --all-namespaces | grep -iv running | grep -iv complete
```

CHAPTER 15. INSTALLING IBM CLOUD BARE METAL (CLASSIC)

15.1. PREREQUISITES

You can use installer-provisioned installation to install OpenShift Container Platform on IBM Cloud® Bare Metal (Classic) nodes. This document describes the prerequisites and procedures when installing OpenShift Container Platform on IBM Cloud nodes.

IMPORTANT

Red Hat supports IPMI and PXE on the provisioning network only. Red Hat has not tested Red Fish, virtual media, or other complementary technologies such as Secure Boot on IBM Cloud deployments. A provisioning network is required.

Installer-provisioned installation of OpenShift Container Platform requires:

- One node with Red Hat Enterprise Linux CoreOS (RHCOS) 8.x installed, for running the provisioner
- Three control plane nodes
- One routable network
- One provisioning network

Before starting an installer-provisioned installation of OpenShift Container Platform on IBM Cloud Bare Metal (Classic), address the following prerequisites and requirements.

15.1.1. Setting up IBM Cloud Bare Metal (Classic) infrastructure

To deploy an OpenShift Container Platform cluster on IBM Cloud® Bare Metal (Classic) infrastructure, you must first provision the IBM Cloud nodes.

IMPORTANT

Red Hat supports IPMI and PXE on the **provisioning** network only. Red Hat has not tested Red Fish, virtual media, or other complementary technologies such as Secure Boot on IBM Cloud deployments. The **provisioning** network is required.

You can customize IBM Cloud nodes using the IBM Cloud API. When creating IBM Cloud nodes, you must consider the following requirements.

Use one data center per cluster
All nodes in the OpenShift Container Platform cluster must run in the same IBM Cloud data center.

Create public and private VLANs
Create all nodes with a single public VLAN and a single private VLAN.

Ensure subnets have sufficient IP addresses
IBM Cloud public VLAN subnets use a /**28** prefix by default, which provides 16 IP addresses. That is sufficient for a cluster consisting of three control plane nodes, four worker nodes, and two IP addresses for the API VIP and Ingress VIP on the **baremetal** network. For larger clusters, you might need a smaller

prefix.

IBM Cloud private VLAN subnets use a /**26** prefix by default, which provides 64 IP addresses. IBM Cloud Bare Metal (Classic) uses private network IP addresses to access the Baseboard Management Controller (BMC) of each node. OpenShift Container Platform creates an additional subnet for the **provisioning** network. Network traffic for the **provisioning** network subnet routes through the private VLAN. For larger clusters, you might need a smaller prefix.

Table 15.1. IP addresses per prefix

IP addresses	Prefix
32	/**27**
64	/**26**
128	/**25**
256	/**24**

Configuring NICs

OpenShift Container Platform deploys with two networks:

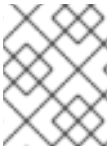
- **provisioning**: The **provisioning** network is a non-routable network used for provisioning the underlying operating system on each node that is a part of the OpenShift Container Platform cluster.
- **baremetal**: The **baremetal** network is a routable network. You can use any NIC order to interface with the **baremetal** network, provided it is not the NIC specified in the **provisioningNetworkInterface** configuration setting or the NIC associated to a node's **bootMACAddress** configuration setting for the **provisioning** network.

While the cluster nodes can contain more than two NICs, the installation process only focuses on the first two NICs. For example:

NIC	Network	VLAN
NIC1	**provisioning**	<provisioning_vlan>
NIC2	**baremetal**	<baremetal_vlan>

In the previous example, NIC1 on all control plane and worker nodes connects to the non-routable network (**provisioning**) that is only used for the installation of the OpenShift Container Platform cluster. NIC2 on all control plane and worker nodes connects to the routable **baremetal** network.

PXE	Boot order
NIC1 PXE-enabled **provisioning** network	1
NIC2 **baremetal** network.	2



NOTE

Ensure PXE is enabled on the NIC used for the **provisioning** network and is disabled on all other NICs.

Configuring canonical names
Clients access the OpenShift Container Platform cluster nodes over the **baremetal** network. Configure IBM Cloud subdomains or subzones where the canonical name extension is the cluster name.

```
<cluster_name>.<domain>
```

For example:

```
test-cluster.example.com
```

Creating DNS entries
You must create DNS **A** record entries resolving to unused IP addresses on the public subnet for the following:

Usage	Host Name	IP
API	api.<cluster_name>.<domain>	<ip>
Ingress LB (apps)	*.apps.<cluster_name>.<domain>	<ip>

Control plane and worker nodes already have DNS entries after provisioning.

The following table provides an example of fully qualified domain names. The API and Nameserver addresses begin with canonical name extensions. The host names of the control plane and worker nodes are examples, so you can use any host naming convention you prefer.

Usage	Host Name	IP
API	api.<cluster_name>.<domain>	<ip>
Ingress LB (apps)	*.apps.<cluster_name>.<domain>	<ip>
Provisioner node	provisioner.<cluster_name>.<domain>	<ip>
Master-0	openshift-master-0.<cluster_name>.<domain>	<ip>
Master-1	openshift-master-1.<cluster_name>.<domain>	<ip>
Master-2	openshift-master-2.<cluster_name>.<domain>	<ip>

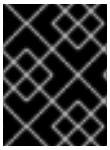
Usage	Host Name	IP
Worker-0	openshift-worker-0. <cluster_name>.<domain>	<ip>
Worker-1	openshift-worker-1. <cluster_name>.<domain>	<ip>
Worker-n	openshift-worker-n. <cluster_name>.<domain>	<ip>

OpenShift Container Platform includes functionality that uses cluster membership information to generate **A** records. This resolves the node names to their IP addresses. After the nodes are registered with the API, the cluster can disperse node information without using CoreDNS-mDNS. This eliminates the network traffic associated with multicast DNS.

IMPORTANT

After provisioning the IBM Cloud nodes, you must create a DNS entry for the **api.<cluster_name>.<domain>** domain name on the external DNS because removing CoreDNS causes the local entry to disappear. Failure to create a DNS record for the **api.<cluster_name>.<domain>** domain name in the external DNS server prevents worker nodes from joining the cluster.

Network Time Protocol (NTP)
Each OpenShift Container Platform node in the cluster must have access to an NTP server. OpenShift Container Platform nodes use NTP to synchronize their clocks. For example, cluster nodes use SSL certificates that require validation, which might fail if the date and time between the nodes are not in sync.



IMPORTANT

Define a consistent clock date and time format in each cluster node's BIOS settings, or installation might fail.

Configure a DHCP server
IBM Cloud Bare Metal (Classic) does not run DHCP on the public or private VLANs. After provisioning IBM Cloud nodes, you must set up a DHCP server for the public VLAN, which corresponds to OpenShift Container Platform's **baremetal** network.

NOTE

The IP addresses allocated to each node do not need to match the IP addresses allocated by the IBM Cloud Bare Metal (Classic) provisioning system.

See the "Configuring the public subnet" section for details.

Ensure BMC access privileges
The "Remote management" page for each node on the dashboard contains the node's intelligent platform management interface (IPMI) credentials. The default IPMI privileges prevent the user from

making certain boot target changes. You must change the privilege level to **OPERATOR** so that Ironic can make those changes.

In the **install-config.yaml** file, add the **privilegelevel** parameter to the URLs used to configure each BMC. See the "Configuring the install-config.yaml file" section for additional details. For example:

```
ipmi://<IP>:<port>?privilegelevel=OPERATOR
```

Alternatively, contact IBM Cloud support and request that they increase the IPMI privileges to **ADMINISTRATOR** for each node.

Create bare metal servers
Create bare metal servers in the IBM Cloud dashboard by navigating to **Create resource → Bare Metal Servers for Classic**.

Alternatively, you can create bare metal servers with the **ibmcloud** CLI utility. For example:

```
$ ibmcloud sl hardware create --hostname <SERVERNAME> \
                      --domain <DOMAIN> \
                      --size <SIZE> \
                      --os <OS-TYPE> \
                      --datacenter <DC-NAME> \
                      --port-speed <SPEED> \
                      --billing <BILLING>
```

See Installing the stand-alone IBM Cloud CLI for details on installing the IBM Cloud CLI.

NOTE

IBM Cloud servers might take 3-5 hours to become available.

15.2. SETTING UP THE ENVIRONMENT FOR AN OPENSHIFT CONTAINER PLATFORM INSTALLATION

15.2.1. Preparing the provisioner node on IBM Cloud Bare Metal (Classic) infrastructure

Perform the following steps to prepare the provisioner node.

Procedure

1. Log in to the provisioner node via **ssh**.
2. Create a non-root user (**kni**) and provide that user with **sudo** privileges:

```
# useradd kni
```

```
# passwd kni
```

```
# echo "kni ALL=(root) NOPASSWD:ALL" | tee -a /etc/sudoers.d/kni
```

```
# chmod 0440 /etc/sudoers.d/kni
```

3. Create an **ssh** key for the new user:

```
# su - kni -c "ssh-keygen -f /home/kni/.ssh/id_rsa -N ""
```

4. Log in as the new user on the provisioner node:

```
# su - kni
```

5. Use Red Hat Subscription Manager to register the provisioner node:

```
$ sudo subscription-manager register --username=<user> --password=<pass> --auto-attach
```

```
$ sudo subscription-manager repos --enable=rhel-8-for-x86_64-appstream-rpms \
                                  --enable=rhel-8-for-x86_64-baseos-rpms
```

NOTE

For more information about Red Hat Subscription Manager, see Using and Configuring Red Hat Subscription Manager.

6. Install the following packages:

```
$ sudo dnf install -y libvirt qemu-kvm mkisofs python3-devel jq ipmitool
```

7. Modify the user to add the **libvirt** group to the newly created user:

```
$ sudo usermod --append --groups libvirt kni
```

8. Start **firewalld**:

```
$ sudo systemctl start firewalld
```

9. Enable **firewalld**:

```
$ sudo systemctl enable firewalld
```

10. Start the **http** service:

```
$ sudo firewall-cmd --zone=public --add-service=http --permanent
```

```
$ sudo firewall-cmd --reload
```

11. Start and enable the **libvirtd** service:

```
$ sudo systemctl enable libvirtd --now
```

12. Set the ID of the provisioner node:

```
$ PRVN_HOST_ID=<ID>
```

You can view the ID with the following **ibmcloud** command:

```
$ ibmcloud sl hardware list
```

13. Set the ID of the public subnet:

```
$ PUBLICSUBNETID=<ID>
```

You can view the ID with the following **ibmcloud** command:

```
$ ibmcloud sl subnet list
```

14. Set the ID of the private subnet:

```
$ PRIVSUBNETID=<ID>
```

You can view the ID with the following **ibmcloud** command:

```
$ ibmcloud sl subnet list
```

15. Set the provisioner node public IP address:

```
$ PRVN_PUB_IP=$(ibmcloud sl hardware detail $PRVN_HOST_ID --output JSON | jq
.primaryIpAddress -r)
```

16. Set the CIDR for the public network:

```
$ PUBLICCIDR=$(ibmcloud sl subnet detail $PUBLICSUBNETID --output JSON | jq .cidr)
```

17. Set the IP address and CIDR for the public network:

```
$ PUB_IP_CIDR=$PRVN_PUB_IP/$PUBLICCIDR
```

18. Set the gateway for the public network:

```
$ PUB_GATEWAY=$(ibmcloud sl subnet detail $PUBLICSUBNETID --output JSON | jq
.gateway -r)
```

19. Set the private IP address of the provisioner node:

```
$ PRVN_PRIV_IP=$(ibmcloud sl hardware detail $PRVN_HOST_ID --output JSON | \
          jq .primaryBackendIpAddress -r)
```

20. Set the CIDR for the private network:

```
$ PRIVCIDR=$(ibmcloud sl subnet detail $PRIVSUBNETID --output JSON | jq .cidr)
```

21. Set the IP address and CIDR for the private network:

```
$ PRIV_IP_CIDR=$PRVN_PRIV_IP/$PRIVCIDR
```

22. Set the gateway for the private network:

```
$ PRIV_GATEWAY=$(ibmcloud sl subnet detail $PRIVSUBNETID --output JSON | jq
.gateway -r)
```

23. Set up the bridges for the **baremetal** and **provisioning** networks:

```
$ sudo nohup bash -c "
    nmcli --get-values UUID con show | xargs -n 1 nmcli con delete
    nmcli connection add ifname provisioning type bridge con-name provisioning
    nmcli con add type bridge-slave ifname eth1 master provisioning
    nmcli connection add ifname baremetal type bridge con-name baremetal
    nmcli con add type bridge-slave ifname eth2 master baremetal
    nmcli connection modify baremetal ipv4.addresses $PUB_IP_CIDR ipv4.method manual
ipv4.gateway $PUB_GATEWAY
    nmcli connection modify provisioning ipv4.addresses 172.22.0.1/24,$PRIV_IP_CIDR
ipv4.method manual
    nmcli connection modify provisioning +ipv4.routes \"10.0.0.0/8 $PRIV_GATEWAY\"
    nmcli con down baremetal
    nmcli con up baremetal
    nmcli con down provisioning
    nmcli con up provisioning
    init 6
"
```

NOTE

For **eth1** and **eth2**, substitute the appropriate interface name, as needed.

24. If required, SSH back into the **provisioner** node:

```
# ssh kni@provisioner.<cluster-name>.<domain>
```

25. Verify the connection bridges have been properly created:

```
$ sudo nmcli con show
```

Example output

```
NAME               UUID                                  TYPE      DEVICE
baremetal          4d5133a5-8351-4bb9-bfd4-3af264801530  bridge    baremetal
provisioning       43942805-017f-4d7d-a2c2-7cb3324482ed  bridge    provisioning
virbr0             d9bca40f-eee1-410b-8879-a2d4bb0465e7  bridge    virbr0
bridge-slave-eth1  76a8ed50-c7e5-4999-b4f6-6d9014dd0812  ethernet  eth1
bridge-slave-eth2  f31c3353-54b7-48de-893a-02d2b34c4736  ethernet  eth2
```

26. Create a **pull-secret.txt** file:

```
$ vim pull-secret.txt
```

In a web browser, navigate to Install on Bare Metal with user-provisioned infrastructure . In step 1, click **Download pull secret**. Paste the contents into the **pull-secret.txt** file and save the contents in the **kni** user's home directory.

15.2.2. Configuring the public subnet

All of the OpenShift Container Platform cluster nodes must be on the public subnet. IBM Cloud® Bare Metal (Classic) does not provide a DHCP server on the subnet. Set it up separately on the provisioner node.

You must reset the BASH variables defined when preparing the provisioner node. Rebooting the provisioner node after preparing it will delete the BASH variables previously set.

Procedure

1. Install **dnsmasq**:

```
$ sudo dnf install dnsmasq
```

2. Open the **dnsmasq** configuration file:

```
$ sudo vi /etc/dnsmasq.conf
```

3. Add the following configuration to the **dnsmasq** configuration file:

```
interface=baremetal
except-interface=lo
bind-dynamic
log-dhcp

dhcp-range=<ip_addr>,<ip_addr>,<pub_cidr> 1
dhcp-option=baremetal,121,0.0.0.0/0,<pub_gateway>,<prvn_priv_ip>,<prvn_pub_ip> 2

dhcp-hostsfile=/var/lib/dnsmasq/dnsmasq.hostsfile
```

1. Set the DHCP range. Replace both instances of **<ip_addr>** with one unused IP address from the public subnet so that the **dhcp-range** for the **baremetal** network begins and ends with the same the IP address. Replace **<pub_cidr>** with the CIDR of the public subnet.

2. Set the DHCP option. Replace **<pub_gateway>** with the IP address of the gateway for the **baremetal** network. Replace **<prvn_priv_ip>** with the IP address of the provisioner node's private IP address on the **provisioning** network. Replace **<prvn_pub_ip>** with the IP address of the provisioner node's public IP address on the **baremetal** network.

To retrieve the value for **<pub_cidr>**, execute:

```
$ ibmcloud sl subnet detail <publicsubnetid> --output JSON | jq .cidr
```

Replace **<publicsubnetid>** with the ID of the public subnet.

To retrieve the value for **<pub_gateway>**, execute:

```
$ ibmcloud sl subnet detail <publicsubnetid> --output JSON | jq .gateway -r
```

Replace **<publicsubnetid>** with the ID of the public subnet.

To retrieve the value for **<prvn_priv_ip>**, execute:

```
$ ibmcloud  sl hardware detail <id> --output JSON | \
          jq .primaryBackendIpAddress -r
```

Replace **<id>** with the ID of the provisioner node.

To retrieve the value for **<prvn_pub_ip>**, execute:

```
$ ibmcloud sl hardware detail <id> --output JSON | jq .primaryIpAddress -r
```

Replace **<id>** with the ID of the provisioner node.

4. Obtain the list of hardware for the cluster:

```
$ ibmcloud sl hardware list
```

5. Obtain the MAC addresses and IP addresses for each node:

```
$ ibmcloud sl hardware detail <id> --output JSON | \
  jq '.networkComponents[] | \
  "\(.primaryIpAddress) \(.macAddress)"' | grep -v null
```

Replace **<id>** with the ID of the node.

Example output

```
"10.196.130.144 00:e0:ed:6a:ca:b4"
"141.125.65.215 00:e0:ed:6a:ca:b5"
```

Make a note of the MAC address and IP address of the public network. Make a separate note of the MAC address of the private network, which you will use later in the **install-config.yaml** file. Repeat this procedure for each node until you have all the public MAC and IP addresses for the public **baremetal** network, and the MAC addresses of the private **provisioning** network.

6. Add the MAC and IP address pair of the public **baremetal** network for each node into the **dnsmasq.hostsfile** file:

```
$ sudo vim /var/lib/dnsmasq/dnsmasq.hostsfile
```

Example input

```
00:e0:ed:6a:ca:b5,141.125.65.215,master-0
<mac>,<ip>,master-1
<mac>,<ip>,master-2
<mac>,<ip>,worker-0
<mac>,<ip>,worker-1
...
```

Replace **<mac>,<ip>** with the public MAC address and public IP address of the corresponding node name.

7. Start **dnsmasq**:

```
$ sudo systemctl start dnsmasq
```

8. Enable **dnsmasq** so that it starts when booting the node:

```
$ sudo systemctl enable dnsmasq
```

9. Verify **dnsmasq** is running:

```
$ sudo systemctl status dnsmasq
```

Example output

```
● dnsmasq.service - DNS caching server.
Loaded: loaded (/usr/lib/systemd/system/dnsmasq.service; enabled; vendor preset: disabled)
Active: active (running) since Tue 2021-10-05 05:04:14 CDT; 49s ago
Main PID: 3101 (dnsmasq)
Tasks: 1 (limit: 204038)
Memory: 732.0K
CGroup: /system.slice/dnsmasq.service
└─3101 /usr/sbin/dnsmasq -k
```

10. Open ports **53** and **67** with UDP protocol:

```
$ sudo firewall-cmd --add-port 53/udp --permanent
```

```
$ sudo firewall-cmd --add-port 67/udp --permanent
```

11. Add **provisioning** to the external zone with masquerade:

```
$ sudo firewall-cmd --change-zone=provisioning --zone=external --permanent
```

This step ensures network address translation for IPMI calls to the management subnet.

12. Reload the **firewalld** configuration:

```
$ sudo firewall-cmd --reload
```

15.2.3. Retrieving the OpenShift Container Platform installer

Use the **stable-4.x** version of the installation program and your selected architecture to deploy the generally available stable version of OpenShift Container Platform:

```
$ export VERSION=stable-4.11
```

```
$ export RELEASE_ARCH=<architecture>
```

```
$ export RELEASE_IMAGE=$(curl -s https://mirror.openshift.com/pub/openshift-v4/$RELEASE_ARCH/clients/ocp/$VERSION/release.txt | grep 'Pull From: quay.io' | awk -F ' ' '{print $3}')
```

15.2.4. Extracting the OpenShift Container Platform installer

After retrieving the installer, the next step is to extract it.

Procedure

1. Set the environment variables:

```
$ export cmd=openshift-baremetal-install
```

```
$ export pullsecret_file=~/pull-secret.txt
```

```
$ export extract_dir=$(pwd)
```

2. Get the **oc** binary:

```
$ curl -s https://mirror.openshift.com/pub/openshift-v4/clients/ocp/$VERSION/openshift-client-linux.tar.gz | tar zxvf - oc
```

3. Extract the installer:

```
$ sudo cp oc /usr/local/bin
```

```
$ oc adm release extract --registry-config "${pullsecret_file}" --command=$cmd --to "${extract_dir}" ${RELEASE_IMAGE}
```

```
$ sudo cp openshift-baremetal-install /usr/local/bin
```

15.2.5. Configuring the install-config.yaml file

The **install-config.yaml** file requires some additional details. Most of the information is teaching the installer and the resulting cluster enough about the available IBM Cloud® Bare Metal (Classic) hardware so that it is able to fully manage it. The material difference between installing on bare metal and installing on IBM Cloud Bare Metal (Classic) is that you must explicitly set the privilege level for IPMI in the BMC section of the **install-config.yaml** file.

Procedure

1. Configure **install-config.yaml**. Change the appropriate variables to match the environment, including **pullSecret** and **sshKey**.

```
apiVersion: v1
baseDomain: <domain>
metadata:
  name: <cluster_name>
networking:
  machineNetwork:
  - cidr: <public-cidr>
  networkType: OVNKubernetes
compute:
- name: worker
  replicas: 2
```

```
controlPlane:
  name: master
  replicas: 3
  platform:
    baremetal: {}
platform:
  baremetal:
    apiVIP: <api_ip>
    ingressVIP: <wildcard_ip>
    provisioningNetworkInterface: <NIC1>
    provisioningNetworkCIDR: <CIDR>
    hosts:
      - name: openshift-master-0
        role: master
        bmc:
          address: ipmi://10.196.130.145?privilegelevel=OPERATOR 1
          username: root
          password: <password>
        bootMACAddress: 00:e0:ed:6a:ca:b4 2
        rootDeviceHints:
          deviceName: "/dev/sda"
      - name: openshift-worker-0
        role: worker
        bmc:
          address: ipmi://<out-of-band-ip>?privilegelevel=OPERATOR 3
          username: <user>
          password: <password>
        bootMACAddress: <NIC1_mac_address> 4
        rootDeviceHints:
          deviceName: "/dev/sda"
pullSecret: '<pull_secret>'
sshKey: '<ssh_pub_key>'
```

1 3 The **bmc.address** provides a **privilegelevel** configuration setting with the value set to **OPERATOR**. This is required for IBM Cloud Bare Metal (Classic) infrastructure.

2 4 Add the MAC address of the private **provisioning** network NIC for the corresponding node.

NOTE

You can use the **ibmcloud** command-line utility to retrieve the password.

```
$ ibmcloud sl hardware detail <id> --output JSON | \
  jq '"(.networkManagementIpAddress)
(.remoteManagementAccounts[0].password)"'
```

Replace **<id>** with the ID of the node.

2. Create a directory to store the cluster configuration:

```
$ mkdir ~/clusterconfigs
```

3. Copy the **install-config.yaml** file into the directory:

```
$ cp install-config.yaml ~/clusterconfig
```

4. Ensure all bare metal nodes are powered off prior to installing the OpenShift Container Platform cluster:

```
$ ipmitool -I lanplus -U <user> -P <password> -H <management_server_ip> power off
```

5. Remove old bootstrap resources if any are left over from a previous deployment attempt:

```
for i in $(sudo virsh list | tail -n +3 | grep bootstrap | awk {'print $2'});
do
  sudo virsh destroy $i;
  sudo virsh undefine $i;
  sudo virsh vol-delete $i --pool $i;
  sudo virsh vol-delete $i.ign --pool $i;
  sudo virsh pool-destroy $i;
  sudo virsh pool-undefine $i;
done
```

15.2.6. Additional **install-config** parameters

See the following tables for the required parameters, the **hosts** parameter, and the **bmc** parameter for the **install-config.yaml** file.

Table 15.2. Required parameters

Parameters	Default	Description
baseDomain		The domain name for the cluster. For example, **example.com**.
bootMode	**UEFI**	The boot mode for a node. Options are **legacy**, **UEFI**, and **UEFISecureBoot**. If **bootMode** is not set, Ironic sets it while inspecting the node.
bootstrapExternalStaticIP		The static IP address for the bootstrap VM. You must set this value when deploying a cluster with static IP addresses when there is no DHCP server on the bare-metal network.
bootstrapExternalStaticGateway		The static IP address of the gateway for the bootstrap VM. You must set this value when deploying a cluster with static IP addresses when there is no DHCP server on the bare-metal network.

Parameters	Default	Description
sshKey		The **sshKey** configuration setting contains the key in the **~/.ssh/id_rsa.pub** file required to access the control plane nodes and worker nodes. Typically, this key is from the **provisioner** node.
pullSecret		The **pullSecret** configuration setting contains a copy of the pull secret downloaded from the Install OpenShift on Bare Metal page when preparing the provisioner node.
metadata: name:		The name to be given to the OpenShift Container Platform cluster. For example, **openshift**.
networking: machineNetwork: - cidr:		The public CIDR (Classless Inter-Domain Routing) of the external network. For example, **10.0.0.0/24**.
compute: - name: worker		The OpenShift Container Platform cluster requires a name be provided for worker (or compute) nodes even if there are zero nodes.
compute: replicas: 2		Replicas sets the number of worker (or compute) nodes in the OpenShift Container Platform cluster.
controlPlane: name: master		The OpenShift Container Platform cluster requires a name for control plane (master) nodes.
controlPlane: replicas: 3		Replicas sets the number of control plane (master) nodes included as part of the OpenShift Container Platform cluster.

Parameters	Default	Description
provisioningNetworkInterface		The name of the network interface on nodes connected to the provisioning network. For OpenShift Container Platform 4.9 and later releases, use the **bootMACAddress** configuration setting to enable Ironic to identify the IP address of the NIC instead of using the **provisioningNetworkInterface** configuration setting to identify the name of the NIC.
defaultMachinePlatform		The default configuration used for machine pools without a platform configuration.
apiVIP		(Optional) The virtual IP address for Kubernetes API communication. This setting must either be provided in the **install-config.yaml** file as a reserved IP from the MachineNetwork or pre-configured in the DNS so that the default name resolves correctly. Use the virtual IP address and not the FQDN when adding a value to the **apiVIP** configuration setting in the **install-config.yaml** file. The IP address must be from the primary IPv4 network when using dual stack networking. If not set, the installer uses **api.<cluster_name>.<base_domain>** to derive the IP address from the DNS.
disableCertificateVerification	**False**	**redfish** and **redfish-virtualmedia** need this parameter to manage BMC addresses. The value should be **True** when using a self-signed certificate for BMC addresses.

Parameters	Default	Description
ingressVIP		(Optional) The virtual IP address for ingress traffic. This setting must either be provided in the **install-config.yaml** file as a reserved IP from the MachineNetwork or pre-configured in the DNS so that the default name resolves correctly. Use the virtual IP address and not the FQDN when adding a value to the **ingressVIP** configuration setting in the **install-config.yaml** file. The IP address must be from the primary IPv4 network when using dual stack networking. If not set, the installer uses **test.apps.<cluster_name>.<base_domain>** to derive the IP address from the DNS.

Table 15.3. Optional Parameters

Parameters	Default	Description
provisioningDHCPRange	**172.22.0.10,172.22.0.100**	Defines the IP range for nodes on the provisioning network.
provisioningNetworkCIDR	**172.22.0.0/24**	The CIDR for the network to use for provisioning. This option is required when not using the default address range on the provisioning network.
clusterProvisioningIP	The third IP address of the **provisioningNetworkCIDR**.	The IP address within the cluster where the provisioning services run. Defaults to the third IP address of the provisioning subnet. For example, **172.22.0.3**.
bootstrapProvisioningIP	The second IP address of the **provisioningNetworkCIDR**.	The IP address on the bootstrap VM where the provisioning services run while the installer is deploying the control plane (master) nodes. Defaults to the second IP address of the provisioning subnet. For example, **172.22.0.2** or **2620:52:0:1307::2**.
externalBridge	**baremetal**	The name of the bare-metal bridge of the hypervisor attached to the bare-metal network.
provisioningBridge	**provisioning**	The name of the provisioning bridge on the **provisioner** host attached to the provisioning network.

Parameters	Default	Description
architecture		Defines the host architecture for your cluster. Valid values are **amd64** or **arm64**.
defaultMachinePlatform		The default configuration used for machine pools without a platform configuration.
bootstrapOSImage		A URL to override the default operating system image for the bootstrap node. The URL must contain a SHA-256 hash of the image. For example: **https://mirror.openshift.com/rhcos-<version>-qemu.qcow2.gz?sha256=<uncompressed_sha256>**.
provisioningNetwork		The **provisioningNetwork** configuration setting determines whether the cluster uses the provisioning network. If it does, the configuration setting also determines if the cluster manages the network. **Disabled**: Set this parameter to **Disabled** to disable the requirement for a provisioning network. When set to **Disabled**, you must only use virtual media based provisioning, or bring up the cluster using the assisted installer. If **Disabled** and using power management, BMCs must be accessible from the bare-metal network. If **Disabled**, you must provide two IP addresses on the bare-metal network that are used for the provisioning services. **Managed**: Set this parameter to **Managed**, which is the default, to fully manage the provisioning network, including DHCP, TFTP, and so on. **Unmanaged**: Set this parameter to **Unmanaged** to enable the provisioning network but take care of manual configuration of DHCP. Virtual media provisioning is recommended but PXE is still available if required.
httpProxy		Set this parameter to the appropriate HTTP proxy used within your environment.
httpsProxy		Set this parameter to the appropriate HTTPS proxy used within your environment.
noProxy		Set this parameter to the appropriate list of exclusions for proxy usage within your environment.

Hosts

The **hosts** parameter is a list of separate bare metal assets used to build the cluster.

Table 15.4. Hosts

Name	Default	Description
name		The name of the **BareMetalHost** resource to associate with the details. For example, **openshift-master-0**.
role		The role of the bare metal node. Either **master** or **worker**.
bmc		Connection details for the baseboard management controller. See the BMC addressing section for additional details.
bootMACAddress		The MAC address of the NIC that the host uses for the provisioning network. Ironic retrieves the IP address using the **bootMACAddress** configuration setting. Then, it binds to the host.  NOTE You must provide a valid MAC address from the host if you disabled the provisioning network.
networkConfig		Set this optional parameter to configure the network interface of a host. See "(Optional) Configuring host network interfaces" for additional details.

15.2.7. Root device hints

The **rootDeviceHints** parameter enables the installer to provision the Red Hat Enterprise Linux CoreOS (RHCOS) image to a particular device. The installer examines the devices in the order it discovers them, and compares the discovered values with the hint values. The installer uses the first discovered device that matches the hint value. The configuration can combine multiple hints, but a device must match all hints for the installer to select it.

Table 15.5. Subfields

Subfield	Description
deviceName	A string containing a Linux device name like **/dev/vda**. The hint must match the actual value exactly.
hctl	A string containing a SCSI bus address like **0:0:0:0**. The hint must match the actual value exactly.
model	A string containing a vendor-specific device identifier. The hint can be a substring of the actual value.

Subfield	Description
vendor	A string containing the name of the vendor or manufacturer of the device. The hint can be a sub-string of the actual value.
serialNumber	A string containing the device serial number. The hint must match the actual value exactly.
minSizeGigabytes	An integer representing the minimum size of the device in gigabytes.
wwn	A string containing the unique storage identifier. The hint must match the actual value exactly.
wwnWithExtension	A string containing the unique storage identifier with the vendor extension appended. The hint must match the actual value exactly.
wwnVendorExtension	A string containing the unique vendor storage identifier. The hint must match the actual value exactly.
rotational	A boolean indicating whether the device should be a rotating disk (true) or not (false).

Example usage

```
 - name: master-0
   role: master
   bmc:
     address: ipmi://10.10.0.3:6203
     username: admin
     password: redhat
   bootMACAddress: de:ad:be:ef:00:40
   rootDeviceHints:
     deviceName: "/dev/sda"
```

15.2.8. Creating the OpenShift Container Platform manifests

1. Create the OpenShift Container Platform manifests.

```
$ ./openshift-baremetal-install --dir ~/clusterconfigs create manifests
```

```
INFO Consuming Install Config from target directory
WARNING Making control-plane schedulable by setting MastersSchedulable to true for
Scheduler cluster settings
WARNING Discarding the OpenShift Manifest that was provided in the target directory
because its dependencies are dirty and it needs to be regenerated
```

15.2.9. Deploying the cluster via the OpenShift Container Platform installer

Run the OpenShift Container Platform installer:

```
$ ./openshift-baremetal-install --dir ~/clusterconfigs --log-level debug create cluster
```

15.2.10. Following the installation

During the deployment process, you can check the installation's overall status by issuing the **tail** command to the **.openshift_install.log** log file in the install directory folder:

```
$ tail -f /path/to/install-dir/.openshift_install.log
```

CHAPTER 16. INSTALLING WITH Z/VM ON IBM Z AND LINUXONE

16.1. PREPARING TO INSTALL WITH Z/VM ON IBM Z AND LINUXONE

16.1.1. Prerequisites

- You reviewed details about the OpenShift Container Platform installation and update processes.
- You read the documentation on selecting a cluster installation method and preparing it for users.

16.1.2. Choosing a method to install OpenShift Container Platform with z/VM on IBM Z or LinuxONE

You can install a cluster with z/VM on IBM Z or LinuxONE infrastructure that you provision, by using one of the following methods:

- **Installing a cluster with z/VM on IBM Z and LinuxONE**: You can install OpenShift Container Platform with z/VM on IBM Z or LinuxONE infrastructure that you provision.
- **Installing a cluster with z/VM on IBM Z and LinuxONE in a restricted network**: You can install OpenShift Container Platform with z/VM on IBM Z or LinuxONE infrastructure that you provision in a restricted or disconnected network, by using an internal mirror of the installation release content. You can use this method to install a cluster that does not require an active internet connection to obtain the software components. You can also use this installation method to ensure that your clusters only use container images that satisfy your organizational controls on external content.

16.2. INSTALLING A CLUSTER WITH Z/VM ON IBM Z AND LINUXONE

In OpenShift Container Platform version 4.11, you can install a cluster on IBM Z or LinuxONE infrastructure that you provision.

NOTE

While this document refers only to IBM Z, all information in it also applies to LinuxONE.

IMPORTANT

Additional considerations exist for non-bare metal platforms. Review the information in the guidelines for deploying OpenShift Container Platform on non-tested platforms before you install an OpenShift Container Platform cluster.

16.2.1. Prerequisites

- You reviewed details about the OpenShift Container Platform installation and update processes.
- You read the documentation on selecting a cluster installation method and preparing it for users.

- Before you begin the installation process, you must clean the installation directory. This ensures that the required installation files are created and updated during the installation process.
- You provisioned persistent storage using OpenShift Data Foundation or other supported storage protocols for your cluster. To deploy a private image registry, you must set up persistent storage with **ReadWriteMany** access.
- If you use a firewall, you configured it to allow the sites that your cluster requires access to.

NOTE

Be sure to also review this site list if you are configuring a proxy.

16.2.2. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.11, you require access to the internet to install your cluster.

You must have internet access to:

- Access OpenShift Cluster Manager Hybrid Cloud Console to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access Quay.io to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.

IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

16.2.3. Requirements for a cluster with user-provisioned infrastructure

For a cluster that contains user-provisioned infrastructure, you must deploy all of the required machines.

This section describes the requirements for deploying OpenShift Container Platform on user-provisioned infrastructure.

16.2.3.1. Required machines for cluster installation

The smallest OpenShift Container Platform clusters require the following hosts:

Table 16.1. Minimum required hosts

Hosts	Description

Hosts	Description
One temporary bootstrap machine	The cluster requires the bootstrap machine to deploy the OpenShift Container Platform cluster on the three control plane machines. You can remove the bootstrap machine after you install the cluster.
Three control plane machines	The control plane machines run the Kubernetes and OpenShift Container Platform services that form the control plane.
At least two compute machines, which are also known as worker machines.	The workloads requested by OpenShift Container Platform users run on the compute machines.

IMPORTANT

To improve high availability of your cluster, distribute the control plane machines over different z/VM instances on at least two physical machines.

The bootstrap, control plane, and compute machines must use Red Hat Enterprise Linux CoreOS (RHCOS) as the operating system.

Note that RHCOS is based on Red Hat Enterprise Linux (RHEL) 8 and inherits all of its hardware certifications and requirements. See Red Hat Enterprise Linux technology capabilities and limits .

16.2.3.2. Minimum resource requirements for cluster installation

Each cluster machine must meet the following minimum requirements:

Table 16.2. Minimum resource requirements

Machine	Operating System	vCPU [1]	Virtual RAM	Storage	IOPS
Bootstrap	RHCOS	4	16 GB	100 GB	N/A
Control plane	RHCOS	4	16 GB	100 GB	N/A
Compute	RHCOS	2	8 GB	100 GB	N/A

1. One physical core (IFL) provides two logical cores (threads) when SMT-2 is enabled. The hypervisor can provide two or more vCPUs.

If an instance type for your platform meets the minimum requirements for cluster machines, it is supported to use in OpenShift Container Platform.

Additional resources

- Optimizing storage

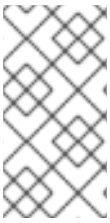
16.2.3.3. Minimum IBM Z system environment

You can install OpenShift Container Platform version 4.11 on the following IBM hardware:

- IBM z16 (all models), IBM z15 (all models), IBM z14 (all models), IBM z13, and IBM z13s
- LinuxONE, any version

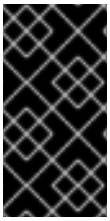
Hardware requirements

- The equivalent of six Integrated Facilities for Linux (IFL), which are SMT2 enabled, for each cluster.
- At least one network connection to both connect to the **LoadBalancer** service and to serve data for traffic outside the cluster.



NOTE

You can use dedicated or shared IFLs to assign sufficient compute resources. Resource sharing is one of the key strengths of IBM Z. However, you must adjust capacity correctly on each hypervisor layer and ensure sufficient resources for every OpenShift Container Platform cluster.



IMPORTANT

Since the overall performance of the cluster can be impacted, the LPARs that are used to setup the OpenShift Container Platform clusters must provide sufficient compute capacity. In this context, LPAR weight management, entitlements, and CPU shares on the hypervisor level play an important role.

Operating system requirements

- One instance of z/VM 7.2 or later

On your z/VM instance, set up:

- Three guest virtual machines for OpenShift Container Platform control plane machines
- Two guest virtual machines for OpenShift Container Platform compute machines
- One guest virtual machine for the temporary OpenShift Container Platform bootstrap machine

IBM Z network connectivity requirements
To install on IBM Z under z/VM, you require a single z/VM virtual NIC in layer 2 mode. You also need:

- A direct-attached OSA or RoCE network adapter
- A z/VM VSwitch set up. For a preferred setup, use OSA link aggregation.

Disk storage for the z/VM guest virtual machines

- FICON attached disk storage (DASDs). These can be z/VM minidisks, fullpack minidisks, or dedicated DASDs, all of which must be formatted as CDL, which is the default. To reach the minimum required DASD size for Red Hat Enterprise Linux CoreOS (RHCOS) installations, you need extended address volumes (EAV). If available, use HyperPAV to ensure optimal performance.

- FCP attached disk storage

Storage / Main Memory

- 16 GB for OpenShift Container Platform control plane machines
- 8 GB for OpenShift Container Platform compute machines
- 16 GB for the temporary OpenShift Container Platform bootstrap machine

16.2.3.4. Preferred IBM Z system environment

Hardware requirements

- Three LPARS that each have the equivalent of six IFLs, which are SMT2 enabled, for each cluster.
- Two network connections to both connect to the **LoadBalancer** service and to serve data for traffic outside the cluster.
- HiperSockets, which are attached to a node either directly as a device or by bridging with one z/VM VSWITCH to be transparent to the z/VM guest. To directly connect HiperSockets to a node, you must set up a gateway to the external network via a RHEL 8 guest to bridge to the HiperSockets network.

Operating system requirements

- Two or three instances of z/VM 7.2 or later for high availability

On your z/VM instances, set up:

- Three guest virtual machines for OpenShift Container Platform control plane machines, one per z/VM instance.
- At least six guest virtual machines for OpenShift Container Platform compute machines, distributed across the z/VM instances.
- One guest virtual machine for the temporary OpenShift Container Platform bootstrap machine.
- To ensure the availability of integral components in an overcommitted environment, increase the priority of the control plane by using the CP command **SET SHARE**. Do the same for infrastructure nodes, if they exist. See SET SHARE in IBM Documentation.

IBM Z network connectivity requirements
To install on IBM Z under z/VM, you require a single z/VM virtual NIC in layer 2 mode. You also need:

- A direct-attached OSA or RoCE network adapter
- A z/VM VSwitch set up. For a preferred setup, use OSA link aggregation.

Disk storage for the z/VM guest virtual machines

- FICON attached disk storage (DASDs). These can be z/VM minidisks, fullpack minidisks, or dedicated DASDs, all of which must be formatted as CDL, which is the default. To reach the minimum required DASD size for Red Hat Enterprise Linux CoreOS (RHCOS) installations, you need extended address volumes (EAV). If available, use HyperPAV and High Performance FICON (zHPF) to ensure optimal performance.

- FCP attached disk storage

Storage / Main Memory

- 16 GB for OpenShift Container Platform control plane machines
- 8 GB for OpenShift Container Platform compute machines
- 16 GB for the temporary OpenShift Container Platform bootstrap machine

16.2.3.5. Certificate signing requests management

Because your cluster has limited access to automatic machine management when you use infrastructure that you provision, you must provide a mechanism for approving cluster certificate signing requests (CSRs) after installation. The **kube-controller-manager** only approves the kubelet client CSRs. The **machine-approver** cannot guarantee the validity of a serving certificate that is requested by using kubelet credentials because it cannot confirm that the correct machine issued the request. You must determine and implement a method of verifying the validity of the kubelet serving certificate requests and approving them.

Additional resources

- See Bridging a HiperSockets LAN with a z/VM Virtual Switch in IBM Documentation.
- See Scaling HyperPAV alias devices on Linux guests on z/VM for performance optimization.
- See Topics in LPAR performance for LPAR weight management and entitlements.
- Recommended host practices for IBM Z & LinuxONE environments

16.2.3.6. Networking requirements for user-provisioned infrastructure

All the Red Hat Enterprise Linux CoreOS (RHCOS) machines require networking to be configured in **initramfs** during boot to fetch their Ignition config files.

During the initial boot, the machines require an HTTP or HTTPS server to establish a network connection to download their Ignition config files.

The machines are configured with static IP addresses. No DHCP server is required. Ensure that the machines have persistent IP addresses and hostnames.

The Kubernetes API server must be able to resolve the node names of the cluster machines. If the API servers and worker nodes are in different zones, you can configure a default DNS search zone to allow the API server to resolve the node names. Another supported approach is to always refer to hosts by their fully-qualified domain names in both the node objects and all DNS requests.

16.2.3.6.1. Network connectivity requirements

You must configure the network connectivity between machines to allow OpenShift Container Platform cluster components to communicate. Each machine must be able to resolve the hostnames of all other machines in the cluster.

This section provides details about the ports that are required.

IMPORTANT

In connected OpenShift Container Platform environments, all nodes are required to have internet access to pull images for platform containers and provide telemetry data to Red Hat.

Table 16.3. Ports used for all-machine to all-machine communications

Protocol	Port	Description
ICMP	N/A	Network reachability tests
TCP	**1936**	Metrics
	9000-**9999**	Host level services, including the node exporter on ports **9100**-**9101** and the Cluster Version Operator on port**9099**.
	10250-**10259**	The default ports that Kubernetes reserves
	10256	openshift-sdn
UDP	**4789**	VXLAN
	6081	Geneve
	9000-**9999**	Host level services, including the node exporter on ports **9100**-**9101**.
	500	IPsec IKE packets
	4500	IPsec NAT-T packets
TCP/UDP	**30000**-**32767**	Kubernetes node port
ESP	N/A	IPsec Encapsulating Security Payload (ESP)

Table 16.4. Ports used for all-machine to control plane communications

Protocol	Port	Description
TCP	**6443**	Kubernetes API

Table 16.5. Ports used for control plane machine to control plane machine communications

Protocol	Port	Description
TCP	**2379**-**2380**	etcd server and peer ports

NTP configuration for user-provisioned infrastructure
OpenShift Container Platform clusters are configured to use a public Network Time Protocol (NTP) server by default. If you want to use a local enterprise NTP server, or if your cluster is being deployed in a disconnected network, you can configure the cluster to use a specific time server. For more information, see the documentation for *Configuring chrony time service* .

Additional resources

- Configuring chrony time service

16.2.3.7. User-provisioned DNS requirements

In OpenShift Container Platform deployments, DNS name resolution is required for the following components:

- The Kubernetes API
- The OpenShift Container Platform application wildcard
- The bootstrap, control plane, and compute machines

Reverse DNS resolution is also required for the Kubernetes API, the bootstrap machine, the control plane machines, and the compute machines.

DNS A/AAAA or CNAME records are used for name resolution and PTR records are used for reverse name resolution. The reverse records are important because Red Hat Enterprise Linux CoreOS (RHCOS) uses the reverse records to set the hostnames for all the nodes, unless the hostnames are provided by DHCP. Additionally, the reverse records are used to generate the certificate signing requests (CSR) that OpenShift Container Platform needs to operate.

The following DNS records are required for a user-provisioned OpenShift Container Platform cluster and they must be in place before installation. In each record, **<cluster_name>** is the cluster name and **<base_domain>** is the base domain that you specify in the **install-config.yaml** file. A complete DNS record takes the form: **<component>.<cluster_name>.<base_domain>.**.

Table 16.6. Required DNS records

Component	Record	Description
Kubernetes API	**api.<cluster_name>.<base_domain>.**	A DNS A/AAAA or CNAME record, and a DNS PTR record, to identify the API load balancer. These records must be resolvable by both clients external to the cluster and from all the nodes within the cluster.

Component	Record	Description
	api-int.<cluster_name>.<base_domain>.	A DNS A/AAAA or CNAME record, and a DNS PTR record, to internally identify the API load balancer. These records must be resolvable from all the nodes within the cluster.  **IMPORTANT** The API server must be able to resolve the worker nodes by the hostnames that are recorded in Kubernetes. If the API server cannot resolve the node names, then proxied API calls can fail, and you cannot retrieve logs from pods.
Routes	***.apps.<cluster_name>.<base_domain>.**	A wildcard DNS A/AAAA or CNAME record that refers to the application ingress load balancer. The application ingress load balancer targets the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default. These records must be resolvable by both clients external to the cluster and from all the nodes within the cluster. For example, **console-openshift-console.apps.<cluster_name>.<base_domain>** is used as a wildcard route to the OpenShift Container Platform console.
Bootstrap machine	**bootstrap.<cluster_name>.<base_domain>.**	A DNS A/AAAA or CNAME record, and a DNS PTR record, to identify the bootstrap machine. These records must be resolvable by the nodes within the cluster.
Control plane machines	**<master><n>.<cluster_name>.<base_domain>.**	DNS A/AAAA or CNAME records and DNS PTR records to identify each machine for the control plane nodes. These records must be resolvable by the nodes within the cluster.
Compute machines	**<worker><n>.<cluster_name>.<base_domain>.**	DNS A/AAAA or CNAME records and DNS PTR records to identify each machine for the worker nodes. These records must be resolvable by the nodes within the cluster.

NOTE

In OpenShift Container Platform 4.4 and later, you do not need to specify etcd host and SRV records in your DNS configuration.

TIP

You can use the **dig** command to verify name and reverse name resolution. See the section on *Validating DNS resolution for user-provisioned infrastructure* for detailed validation steps.

16.2.3.7.1. Example DNS configuration for user-provisioned clusters

This section provides A and PTR record configuration samples that meet the DNS requirements for deploying OpenShift Container Platform on user-provisioned infrastructure. The samples are not meant to provide advice for choosing one DNS solution over another.

In the examples, the cluster name is **ocp4** and the base domain is **example.com**.

Example DNS A record configuration for a user-provisioned cluster

The following example is a BIND zone file that shows sample A records for name resolution in a user-provisioned cluster.

Example 16.1. Sample DNS zone database

```
$TTL 1W
@ IN SOA ns1.example.com. root (
  2019070700 ; serial
  3H  ; refresh (3 hours)
  30M  ; retry (30 minutes)
  2W  ; expiry (2 weeks)
  1W )  ; minimum (1 week)
 IN NS ns1.example.com.
 IN MX 10 smtp.example.com.
;
;
ns1.example.com.  IN A 192.168.1.5
smtp.example.com.  IN A 192.168.1.5
;
helper.example.com.  IN A 192.168.1.5
helper.ocp4.example.com. IN A 192.168.1.5
;
api.ocp4.example.com.  IN A 192.168.1.5 1
api-int.ocp4.example.com. IN A 192.168.1.5 2
;
*.apps.ocp4.example.com. IN A 192.168.1.5 3
;
bootstrap.ocp4.example.com. IN A 192.168.1.96 4
;
master0.ocp4.example.com. IN A 192.168.1.97 5
master1.ocp4.example.com. IN A 192.168.1.98 6
master2.ocp4.example.com. IN A 192.168.1.99 7
;
worker0.ocp4.example.com. IN A 192.168.1.11 8
worker1.ocp4.example.com. IN A 192.168.1.7 9
;
;EOF
```

1 Provides name resolution for the Kubernetes API. The record refers to the IP address of the API load balancer.

2 Provides name resolution for the Kubernetes API. The record refers to the IP address of the API load balancer and is used for internal cluster communications.

3 Provides name resolution for the wildcard routes. The record refers to the IP address of the application ingress load balancer. The application ingress load balancer targets the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.

NOTE

In the example, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

4 Provides name resolution for the bootstrap machine.

5 6 7 Provides name resolution for the control plane machines.

8 9 Provides name resolution for the compute machines.

Example DNS PTR record configuration for a user-provisioned cluster

The following example BIND zone file shows sample PTR records for reverse name resolution in a user-provisioned cluster.

Example 16.2. Sample DNS zone database for reverse records

```
$TTL 1W
@ IN SOA ns1.example.com. root (
  2019070700 ; serial
  3H  ; refresh (3 hours)
  30M  ; retry (30 minutes)
  2W  ; expiry (2 weeks)
  1W )  ; minimum (1 week)
 IN NS ns1.example.com.
;
5.1.168.192.in-addr.arpa. IN PTR api.ocp4.example.com. 1
5.1.168.192.in-addr.arpa. IN PTR api-int.ocp4.example.com. 2
;
96.1.168.192.in-addr.arpa. IN PTR bootstrap.ocp4.example.com. 3
;
97.1.168.192.in-addr.arpa. IN PTR master0.ocp4.example.com. 4
98.1.168.192.in-addr.arpa. IN PTR master1.ocp4.example.com. 5
99.1.168.192.in-addr.arpa. IN PTR master2.ocp4.example.com. 6
;
11.1.168.192.in-addr.arpa. IN PTR worker0.ocp4.example.com. 7
7.1.168.192.in-addr.arpa. IN PTR worker1.ocp4.example.com. 8
;
;EOF
```

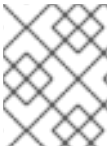
1. Provides reverse DNS resolution for the Kubernetes API. The PTR record refers to the record name of the API load balancer.
2. Provides reverse DNS resolution for the Kubernetes API. The PTR record refers to the record name of the API load balancer and is used for internal cluster communications.
3. Provides reverse DNS resolution for the bootstrap machine.
4. 5. 6. Provides reverse DNS resolution for the control plane machines.
7. 8. Provides reverse DNS resolution for the compute machines.

NOTE

A PTR record is not required for the OpenShift Container Platform application wildcard.

16.2.3.8. Load balancing requirements for user-provisioned infrastructure

Before you install OpenShift Container Platform, you must provision the API and application ingress load balancing infrastructure. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.



NOTE

If you want to deploy the API and application Ingress load balancers with a Red Hat Enterprise Linux (RHEL) instance, you must purchase the RHEL subscription separately.

The load balancing infrastructure must meet the following requirements:

1. **API load balancer**: Provides a common endpoint for users, both human and machine, to interact with and configure the platform. Configure the following conditions:
   - Layer 4 load balancing only. This can be referred to as Raw TCP, SSL Passthrough, or SSL Bridge mode. If you use SSL Bridge mode, you must enable Server Name Indication (SNI) for the API routes.
   - A stateless load balancing algorithm. The options vary based on the load balancer implementation.

IMPORTANT

Do not configure session persistence for an API load balancer. Configuring session persistence for a Kubernetes API server might cause performance issues from excess application traffic for your OpenShift Container Platform cluster and the Kubernetes API that runs inside the cluster.

Configure the following ports on both the front and back of the load balancers:

Table 16.7. API load balancer

Port	Back-end machines (pool members)	Internal	External	Description
6443	Bootstrap and control plane. You remove the bootstrap machine from the load balancer after the bootstrap machine initializes the cluster control plane. You must configure the **/readyz** endpoint for the API server health check probe.	X	X	Kubernetes API server
22623	Bootstrap and control plane. You remove the bootstrap machine from the load balancer after the bootstrap machine initializes the cluster control plane.	X		Machine config server

NOTE

The load balancer must be configured to take a maximum of 30 seconds from the time the API server turns off the **/readyz** endpoint to the removal of the API server instance from the pool. Within the time frame after **/readyz** returns an error or becomes healthy, the endpoint must have been removed or added. Probing every 5 or 10 seconds, with two successful requests to become healthy and three to become unhealthy, are well-tested values.

2. **Application Ingress load balancer**: Provides an ingress point for application traffic flowing in from outside the cluster. A working configuration for the Ingress router is required for an OpenShift Container Platform cluster.
Configure the following conditions:

   - Layer 4 load balancing only. This can be referred to as Raw TCP, SSL Passthrough, or SSL Bridge mode. If you use SSL Bridge mode, you must enable Server Name Indication (SNI) for the ingress routes.
   - A connection-based or session-based persistence is recommended, based on the options available and types of applications that will be hosted on the platform.

TIP

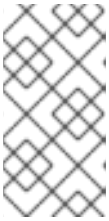
If the true IP address of the client can be seen by the application Ingress load balancer, enabling source IP-based session persistence can improve performance for applications that use end-to-end TLS encryption.

Configure the following ports on both the front and back of the load balancers:

Table 16.8. Application Ingress load balancer

Port	Back-end machines (pool members)	Internal	External	Description

Port	Back-end machines (pool members)	Internal	External	Description
443	The machines that run the Ingress Controller pods, compute, or worker, by default.	X	X	HTTPS traffic
80	The machines that run the Ingress Controller pods, compute, or worker, by default.	X	X	HTTP traffic



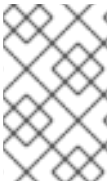
NOTE

If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application Ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes.

16.2.3.8.1. Example load balancer configuration for user-provisioned clusters

This section provides an example API and application ingress load balancer configuration that meets the load balancing requirements for user-provisioned clusters. The sample is an **/etc/haproxy/haproxy.cfg** configuration for an HAProxy load balancer. The example is not meant to provide advice for choosing one load balancing solution over another.

In the example, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.



NOTE

If you are using HAProxy as a load balancer and SELinux is set to **enforcing**, you must ensure that the HAProxy service can bind to the configured TCP port by running **setsebool -P haproxy_connect_any=1**.

Example 16.3. Sample API and application Ingress load balancer configuration

```
global
  log         127.0.0.1 local2
  pidfile     /var/run/haproxy.pid
  maxconn     4000
  daemon
defaults
  mode                    http
  log                     global
  option                  dontlognull
  option http-server-close
  option                  redispatch
  retries                 3
  timeout http-request    10s
  timeout queue           1m
  timeout connect         10s
  timeout client          1m
```

```
  timeout server          1m
  timeout http-keep-alive 10s
  timeout check           10s
  maxconn                 3000
listen api-server-6443 (1)
  bind *:6443
  mode tcp
  server bootstrap bootstrap.ocp4.example.com:6443 check inter 1s backup (2)
  server master0 master0.ocp4.example.com:6443 check inter 1s
  server master1 master1.ocp4.example.com:6443 check inter 1s
  server master2 master2.ocp4.example.com:6443 check inter 1s
listen machine-config-server-22623 (3)
  bind *:22623
  mode tcp
  option  httpchk GET /readyz HTTP/1.0
  option  log-health-checks
  balance roundrobin
  server bootstrap bootstrap.ocp4.example.com:6443 verify none check check-ssl inter 10s fall 2
rise 3 backup (4)
  server master0 master0.ocp4.example.com:6443 weight 1 verify none check check-ssl inter 10s
fall 2 rise 3
  server master1 master1.ocp4.example.com:6443 weight 1 verify none check check-ssl inter 10s
fall 2 rise 3
  server master2 master2.ocp4.example.com:6443 weight 1 verify none check check-ssl inter 10s
fall 2 rise 3
listen ingress-router-443 (5)
  bind *:443
  mode tcp
  balance source
  server worker0 worker0.ocp4.example.com:443 check inter 1s
  server worker1 worker1.ocp4.example.com:443 check inter 1s
listen ingress-router-80 (6)
  bind *:80
  mode tcp
  balance source
  server worker0 worker0.ocp4.example.com:80 check inter 1s
  server worker1 worker1.ocp4.example.com:80 check inter 1s
```

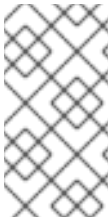
(1) Port **6443** handles the Kubernetes API traffic and points to the control plane machines.

(2) (4) The bootstrap entries must be in place before the OpenShift Container Platform cluster installation and they must be removed after the bootstrap process is complete.

(3) Port **22623** handles the machine config server traffic and points to the control plane machines.

(5) Port **443** handles the HTTPS traffic and points to the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.

(6) Port **80** handles the HTTP traffic and points to the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.



NOTE

If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application Ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes.

TIP

If you are using HAProxy as a load balancer, you can check that the **haproxy** process is listening on ports **6443**, **22623**, **443**, and **80** by running **netstat -nltupe** on the HAProxy node.

16.2.4. Preparing the user-provisioned infrastructure

Before you install OpenShift Container Platform on user-provisioned infrastructure, you must prepare the underlying infrastructure.

This section provides details about the high-level steps required to set up your cluster infrastructure in preparation for an OpenShift Container Platform installation. This includes configuring IP networking and network connectivity for your cluster nodes, preparing a web server for the Ignition files, enabling the required ports through your firewall, and setting up the required DNS and load balancing infrastructure.

After preparation, your cluster infrastructure must meet the requirements outlined in the *Requirements for a cluster with user-provisioned infrastructure* section.

Prerequisites

- You have reviewed the OpenShift Container Platform 4.x Tested Integrations page.
- You have reviewed the infrastructure requirements detailed in the *Requirements for a cluster with user-provisioned infrastructure* section.

Procedure

1. Set up static IP addresses.
2. Set up an HTTP or HTTPS server to provide Ignition files to the cluster nodes.
3. Ensure that your network infrastructure provides the required network connectivity between the cluster components. See the *Networking requirements for user-provisioned infrastructure* section for details about the requirements.
4. Configure your firewall to enable the ports required for the OpenShift Container Platform cluster components to communicate. See *Networking requirements for user-provisioned infrastructure* section for details about the ports that are required.

IMPORTANT

By default, port **1936** is accessible for an OpenShift Container Platform cluster, because each control plane node needs access to this port.

Avoid using the Ingress load balancer to expose this port, because doing so might result in the exposure of sensitive information, such as statistics and metrics, related to Ingress Controllers.

5. Setup the required DNS infrastructure for your cluster.

    a. Configure DNS name resolution for the Kubernetes API, the application wildcard, the bootstrap machine, the control plane machines, and the compute machines.

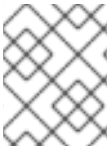
    b. Configure reverse DNS resolution for the Kubernetes API, the bootstrap machine, the control plane machines, and the compute machines.
    See the *User-provisioned DNS requirements* section for more information about the OpenShift Container Platform DNS requirements.

6. Validate your DNS configuration.

    a. From your installation node, run DNS lookups against the record names of the Kubernetes API, the wildcard routes, and the cluster nodes. Validate that the IP addresses in the responses correspond to the correct components.

    b. From your installation node, run reverse DNS lookups against the IP addresses of the load balancer and the cluster nodes. Validate that the record names in the responses correspond to the correct components.
    See the *Validating DNS resolution for user-provisioned infrastructure* section for detailed DNS validation steps.

7. Provision the required API and application ingress load balancing infrastructure. See the *Load balancing requirements for user-provisioned infrastructure* section for more information about the requirements.

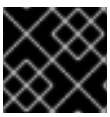


NOTE

Some load balancing solutions require the DNS name resolution for the cluster nodes to be in place before the load balancing is initialized.

16.2.5. Validating DNS resolution for user-provisioned infrastructure

You can validate your DNS configuration before installing OpenShift Container Platform on user-provisioned infrastructure.



IMPORTANT

The validation steps detailed in this section must succeed before you install your cluster.

Prerequisites

- You have configured the required DNS records for your user-provisioned infrastructure.

Procedure

1. From your installation node, run DNS lookups against the record names of the Kubernetes API, the wildcard routes, and the cluster nodes. Validate that the IP addresses contained in the responses correspond to the correct components.

   a. Perform a lookup against the Kubernetes API record name. Check that the result points to the IP address of the API load balancer:

   ```
   $ dig +noall +answer @<nameserver_ip> api.<cluster_name>.<base_domain> 1
   ```

   1 Replace **<nameserver_ip>** with the IP address of the nameserver, **<cluster_name>** with your cluster name, and **<base_domain>** with your base domain name.

   Example output

   ```
   api.ocp4.example.com.  604800 IN A 192.168.1.5
   ```

   b. Perform a lookup against the Kubernetes internal API record name. Check that the result points to the IP address of the API load balancer:

   ```
   $ dig +noall +answer @<nameserver_ip> api-int.<cluster_name>.<base_domain>
   ```

   Example output

   ```
   api-int.ocp4.example.com.  604800 IN A 192.168.1.5
   ```

   c. Test an example ***.apps.<cluster_name>.<base_domain>** DNS wildcard lookup. All of the application wildcard lookups must resolve to the IP address of the application ingress load balancer:

   ```
   $ dig +noall +answer @<nameserver_ip> random.apps.<cluster_name>.<base_domain>
   ```

   Example output

   ```
   random.apps.ocp4.example.com.  604800 IN A 192.168.1.5
   ```

   NOTE

   In the example outputs, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

   You can replace **random** with another wildcard value. For example, you can query the route to the OpenShift Container Platform console:

   ```
   $ dig +noall +answer @<nameserver_ip> console-openshift-console.apps.
   <cluster_name>.<base_domain>
   ```

   Example output

   ```
   console-openshift-console.apps.ocp4.example.com. 604800 IN A 192.168.1.5
   ```

d. Run a lookup against the bootstrap DNS record name. Check that the result points to the IP address of the bootstrap node:

```
$ dig +noall +answer @<nameserver_ip> bootstrap.<cluster_name>.<base_domain>
```

Example output

```
bootstrap.ocp4.example.com.  604800 IN A 192.168.1.96
```

e. Use this method to perform lookups against the DNS record names for the control plane and compute nodes. Check that the results correspond to the IP addresses of each node.

2. From your installation node, run reverse DNS lookups against the IP addresses of the load balancer and the cluster nodes. Validate that the record names contained in the responses correspond to the correct components.

a. Perform a reverse lookup against the IP address of the API load balancer. Check that the response includes the record names for the Kubernetes API and the Kubernetes internal API:

```
$ dig +noall +answer @<nameserver_ip> -x 192.168.1.5
```

Example output

```
5.1.168.192.in-addr.arpa. 604800 IN PTR api-int.ocp4.example.com. 1
5.1.168.192.in-addr.arpa. 604800 IN PTR api.ocp4.example.com. 2
```

1 Provides the record name for the Kubernetes internal API.

2 Provides the record name for the Kubernetes API.

NOTE

A PTR record is not required for the OpenShift Container Platform application wildcard. No validation step is needed for reverse DNS resolution against the IP address of the application ingress load balancer.

b. Perform a reverse lookup against the IP address of the bootstrap node. Check that the result points to the DNS record name of the bootstrap node:

```
$ dig +noall +answer @<nameserver_ip> -x 192.168.1.96
```

Example output

```
96.1.168.192.in-addr.arpa. 604800 IN PTR bootstrap.ocp4.example.com.
```

c. Use this method to perform reverse lookups against the IP addresses for the control plane and compute nodes. Check that the results correspond to the DNS record names of each node.

16.2.6. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the **~/.ssh/authorized_keys** list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The **./openshift-install gather** command also requires the SSH public key to be in place on the cluster nodes.

IMPORTANT

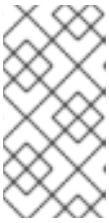
Do not skip this procedure in production environments, where disaster recovery and debugging is required.

Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N '' -f <path>/<file_name> 1
```

1 Specify the path and file name, such as **~/.ssh/id_ed25519**, of the new SSH key. If you have an existing key pair, ensure your public key is in the your **~/.ssh** directory.



NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS validated or Modules In Process cryptographic libraries on the **x86_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

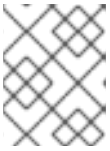
2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the **~/.ssh/id_ed25519.pub** public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the **./openshift-install gather** command.



NOTE

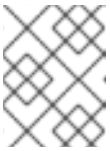
On some distributions, default SSH private key identities such as **~/.ssh/id_rsa** and **~/.ssh/id_dsa** are managed automatically.

a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

Example output

```
Agent pid 31874
```



NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

1 Specify the path and file name for your SSH private key, such as **~/.ssh/id_ed25519**

Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

16.2.7. Obtaining the installation program

Before you install OpenShift Container Platform, download the installation file on your provisioning machine.

Prerequisites

- You have a machine that runs Linux, for example Red Hat Enterprise Linux 8, with 500 MB of local disk space.

Procedure

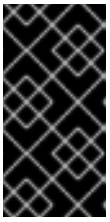
1. Access the Infrastructure Provider page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.

2. Select your infrastructure provider.

3. Navigate to the page for your installation type, download the installation program that corresponds with your host operating system and architecture, and place the file in the directory where you will store the installation configuration files.

IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.



IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

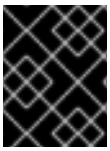
4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation pull secret from the Red Hat OpenShift Cluster Manager . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

16.2.8. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.



IMPORTANT

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.11. Download and install the new version of **oc**.

Installing the OpenShift CLI on Linux
You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the architecture in the **Product Variant** drop-down menu.
3. Select the appropriate version in the **Version** drop-down menu.
4. Click **Download Now** next to the **OpenShift v4.11 Linux Client** entry and save the file.
5. Unpack the archive:

```
$ tar xvf <file>
```

6. Place the **oc** binary in a directory that is on your **PATH**.
   To check your **PATH**, execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.
   To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
C:\> oc <command>
```

Installing the OpenShift CLI on macOS

You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 macOS Client** entry and save the file.

NOTE

For macOS arm64, choose the **OpenShift v4.11 macOS arm64 Client** entry.

4. Unpack and unzip the archive.

5. Move the **oc** binary to a directory on your PATH.
   To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

16.2.9. Manually creating the installation configuration file

Prerequisites

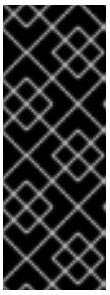
- You have an SSH public key on your local machine to provide to the installation program. The key will be used for SSH authentication onto your cluster nodes for debugging and disaster recovery.

- You have obtained the OpenShift Container Platform installation program and the pull secret for your cluster.

Procedure

1. Create an installation directory to store your required installation assets in:

```
$ mkdir <installation_directory>
```



IMPORTANT

You must create a directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

2. Customize the sample **install-config.yaml** file template that is provided and save it in the **<installation_directory>**.

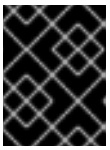
NOTE

You must name this configuration file **install-config.yaml**.

NOTE

For some platform types, you can alternatively run **./openshift-install create install-config --dir <installation_directory>** to generate an **install-config.yaml** file. You can provide details about your cluster configuration at the prompts.

3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.



IMPORTANT

The **install-config.yaml** file is consumed during the next step of the installation process. You must back it up now.

16.2.9.1. Installation configuration parameters

Before you deploy an OpenShift Container Platform cluster, you provide a customized **install-config.yaml** installation configuration file that describes the details for your environment.

NOTE

After installation, you cannot modify these parameters in the **install-config.yaml** file.

16.2.9.1.1. Required configuration parameters

Required installation configuration parameters are described in the following table:

Table 16.9. Required parameters

Parameter	Description	Values
apiVersion	The API version for the **install-config.yaml** content. The current version is **v1**. The installer may also support older API versions.	String
baseDomain	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the **baseDomain** and **metadata.name** parameter values that uses the **<metadata.name>.<baseDomain>** format.	A fully-qualified domain or subdomain name, such as **example.com**.
metadata	Kubernetes resource **ObjectMeta**, from which only the **name** parameter is consumed.	Object

Parameter	Description	Values
metadata.name	The name of the cluster. DNS records for the cluster are all subdomains of **{{.metadata.name}}.{{.baseDomain}}**.	String of lowercase letters, hyphens (**-**), and periods (**.**), such as **dev**.
platform	The configuration for the specific platform upon which to perform the installation: **alibabacloud**, **aws**, **baremetal**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**. For additional information about **platform.<platform>** parameters, consult the table for your specific platform that follows.	Object
pullSecret	Get a pull secret from the Red Hat OpenShift Cluster Manager to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	{ "auths":{ "cloud.openshift.com":{ "auth":"b3Blb=", "email":"you@example.com" }, "quay.io":{ "auth":"b3Blb=", "email":"you@example.com" } } }

16.2.9.1.2. Network configuration parameters

You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

Only IPv4 addresses are supported.

NOTE

Globalnet is not supported with Red Hat OpenShift Data Foundation disaster recovery solutions. For regional disaster recovery scenarios, ensure that you use a nonoverlapping range of private IP addresses for the cluster and service networks in each cluster.

Table 16.10. Network parameters

Parameter	Description	Values
networking	The configuration for the cluster network.	Object  **NOTE** You cannot modify parameters specified by the **networking** object after installation.
networking.networkType	The cluster network provider Container Network Interface (CNI) cluster network provider to install.	Either **OpenShiftSDN** or **OVNKubernetes**. **OpenShiftSDN** is a CNI provider for all-Linux networks. **OVNKubernetes** is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is **OpenShiftSDN**.
networking.clusterNetwork	The IP address blocks for pods. The default value is **10.128.0.0/14** with a host prefix of **/23**. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: `networking:` `  clusterNetwork:` `  - cidr: 10.128.0.0/14` `    hostPrefix: 23`
networking.clusterNetwork.cidr	Required if you use **networking.clusterNetwork**. An IP address block. An IPv4 network.	An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between **0** and **32**.
networking.clusterNetwork.hostPrefix	The subnet prefix length to assign to each individual node. For example, if **hostPrefix** is set to **23** then each node is assigned a **/23** subnet out of the given **cidr**. A **hostPrefix** value of **23** provides 510 (2^(32 - 23) - 2) pod IP addresses.	A subnet prefix. The default value is **23**.
networking.serviceNetwork	The IP address block for services. The default value is **172.30.0.0/16**. The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.	An array with an IP address block in CIDR format. For example: `networking:` `  serviceNetwork:` `  - 172.30.0.0/16`

Parameter	Description	Values
networking.machineNetwork	The IP address blocks for machines. If you specify multiple IP address blocks, the blocks must not overlap. If you specify multiple IP kernel arguments, the **machineNetwork.cidr** value must be the CIDR of the primary network.	An array of objects. For example: `networking:` `  machineNetwork:` `  - cidr: 10.0.0.0/16`
networking.machineNetwork.cidr	Required if you use **networking.machineNetwork**. An IP address block. The default value is **10.0.0.0/16** for all platforms other than libvirt. For libvirt, the default value is **192.168.126.0/24**.	An IP network block in CIDR notation. For example, **10.0.0.0/16**. **NOTE** Set the **networking.machineNetwork** to match the CIDR that the preferred NIC resides in.

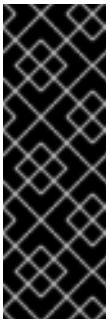
16.2.9.1.3. Optional configuration parameters

Optional installation configuration parameters are described in the following table:

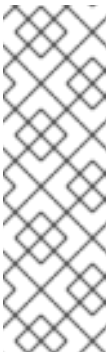
Table 16.11. Optional parameters

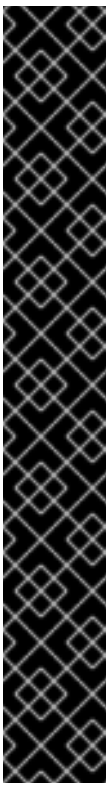
Parameter	Description	Values
additionalTrustBundle	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String
capabilities	Controls the installation of optional core cluster components. You can reduce the footprint of your OpenShift Container Platform cluster by disabling optional components.	String array

Parameter	Description	Values
capabilities.baselineCapabilitySet	Selects an initial set of optional capabilities to enable. Valid values are **None**, **v4.11** and **vCurrent**. **v4.11** enables the **baremetal** Operator, the **marketplace** Operator, and the **openshift-samples** content. **vCurrent** installs the recommended set of capabilities for the current version of OpenShift Container Platform. The default value is **vCurrent**.	String
capabilities.additionalEnabledCapabilities	Extends the set of optional capabilities beyond what you specify in **baselineCapabilitySet**. Valid values are **baremetal**, **marketplace** and **openshift-samples**. You may specify multiple capabilities in this parameter.	String array
cgroupsV2	Enables Linux control groups version 2 (cgroups v2) on specific nodes in your cluster. The OpenShift Container Platform process for enabling cgroups v2 disables all cgroup version 1 controllers and hierarchies. The OpenShift Container Platform cgroups version 2 feature is in Developer Preview and is not supported by Red Hat at this time.	**true**
compute	The configuration for the machines that comprise the compute nodes.	Array of **MachinePool** objects.
compute.architecture	Determines the instruction set architecture of the machines in the pool. Currently, heteregeneous clusters are not supported, so all pools must specify the same architecture. Valid values are **s390x** (the default).	String

Parameter	Description	Values
compute.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  **IMPORTANT** If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
compute.name	Required if you use **compute**. The name of the machine pool.	**worker**
compute.platform	Required if you use **compute**. Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the **controlPlane.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
compute.replicas	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to **2**. The default value is **3**.
controlPlane	The configuration for the machines that comprise the control plane.	Array of **MachinePool** objects.
controlPlane.architecture	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are **s390x** (the default).	String

Parameter	Description	Values
controlPlane.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  **IMPORTANT** If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
controlPlane.name	Required if you use **controlPlane**. The name of the machine pool.	**master**
controlPlane.platform	Required if you use **controlPlane**. Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the **compute.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
controlPlane.replicas	The number of control plane machines to provision.	The only supported value is **3**, which is the default value.

Parameter	Description	Values
credentialsMode	The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported.  **NOTE** Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the *Cloud Credential Operator* entry in the *Cluster Operators reference* content.  **NOTE** If your AWS account has service control policies (SCP) enabled, you must configure the **credentialsMode** parameter to **Mint**, **Passthrough** or **Manual**.	**Mint**, **Passthrough**, **Manual** or an empty string (**""**).

Parameter	Description	Values
fips	Enable or disable FIPS mode. The default is **false** (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.  **IMPORTANT** To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.  **NOTE** If you are using Azure File storage, you cannot enable FIPS mode.	**false** or **true**

Parameter	Description	Values
imageContentSources	Sources and repositories for the release-image content.	Array of objects. Includes a **source** and, optionally, **mirrors**, as described in the following rows of this table.
imageContentSources.source	Required if you use **imageContentSources**. Specify the repository that users refer to, for example, in image pull specifications.	String
imageContentSources.mirrors	Specify one or more repositories that may also contain the same images.	Array of strings
publish	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	**Internal** or **External**. The default value is **External**. Setting this field to **Internal** is not supported on non-cloud platforms and IBM Cloud VPC.  IMPORTANT If the value of the field is set to **Internal**, the cluster will become non-functional. For more information, refer to BZ#1953035.
sshKey	The SSH key to authenticate access to your cluster machines.  NOTE For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.	For example, **sshKey: ssh-ed25519 AAAA..**.

16.2.9.2. Sample install-config.yaml file for IBM Z

You can customize the **install-config.yaml** file to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.

```
apiVersion: v1
baseDomain: example.com (1)
compute: (2)
- hyperthreading: Enabled (3)
  name: worker
  replicas: 0 (4)
  architecture : s390x
controlPlane: (5)
  hyperthreading: Enabled (6)
  name: master
  replicas: 3 (7)
  architecture : s390x
metadata:
  name: test (8)
networking:
  clusterNetwork:
  - cidr: 10.128.0.0/14 (9)
    hostPrefix: 23 (10)
  networkType: OpenShiftSDN
  serviceNetwork: (11)
  - 172.30.0.0/16
platform:
  none: {} (12)
fips: false (13)
pullSecret: '{"auths": ...}' (14)
sshKey: 'ssh-ed25519 AAAA...' (15)
```

(1) The base domain of the cluster. All DNS records must be sub-domains of this base and include the cluster name.

(2) (5) The **controlPlane** section is a single mapping, but the **compute** section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, **-**, and the first line of the **controlPlane** section must not. Only one control plane pool is used.

(3) (6) Specifies whether to enable or disable simultaneous multithreading (SMT), or hyperthreading. By default, SMT is enabled to increase the performance of the cores in your machines. You can disable it by setting the parameter value to **Disabled**. If you disable SMT, you must disable it in all cluster machines; this includes both control plane and compute machines.

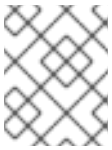
NOTE

Simultaneous multithreading (SMT) is enabled by default. If SMT is not available on your OpenShift Container Platform nodes, the **hyperthreading** parameter has no effect.

IMPORTANT

If you disable **hyperthreading**, whether on your OpenShift Container Platform nodes or in the **install-config.yaml** file, ensure that your capacity planning accounts for the dramatically decreased machine performance.

4 You must set this value to **0** when you install OpenShift Container Platform on user-provisioned infrastructure. In installer-provisioned installations, the parameter controls the number of compute machines that the cluster creates and manages for you. In user-provisioned installations, you must manually deploy the compute machines before you finish installing the cluster.



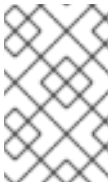
NOTE

If you are installing a three-node cluster, do not deploy any compute machines when you install the Red Hat Enterprise Linux CoreOS (RHCOS) machines.

7 The number of control plane machines that you add to the cluster. Because the cluster uses these values as the number of etcd endpoints in the cluster, the value must match the number of control plane machines that you deploy.

8 The cluster name that you specified in your DNS records.

9 A block of IP addresses from which pod IP addresses are allocated. This block must not overlap with existing physical networks. These IP addresses are used for the pod network. If you need to access the pods from an external network, you must configure load balancers and routers to manage the traffic.



NOTE

Class E CIDR range is reserved for a future use. To use the Class E CIDR range, you must ensure your networking environment accepts the IP addresses within the Class E CIDR range.

10 The subnet prefix length to assign to each individual node. For example, if **hostPrefix** is set to **23**, then each node is assigned a /**23** subnet out of the given **cidr**, which allows for 510 (2^(32 - 23) - 2) pod IP addresses. If you are required to provide access to nodes from an external network, configure load balancers and routers to manage the traffic.

11 The IP address pool to use for service IP addresses. You can enter only one IP address pool. This block must not overlap with existing physical networks. If you need to access the services from an external network, configure load balancers and routers to manage the traffic.

12 You must set the platform to **none**. You cannot provide additional platform configuration variables for IBM Z infrastructure.

IMPORTANT

Clusters that are installed with the platform type **none** are unable to use some features, such as managing compute machines with the Machine API. This limitation applies even if the compute machines that are attached to the cluster are installed on a platform that would normally support the feature. This parameter cannot be changed after installation.

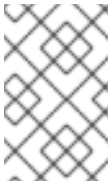
13 Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is

IMPORTANT

To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.

14 The pull secret from the Red Hat OpenShift Cluster Manager . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

15 The SSH public key for the **core** user in Red Hat Enterprise Linux CoreOS (RHCOS).



NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

16.2.9.3. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.

NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
```

```
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
```

1. A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
2. A proxy URL to use for creating HTTPS connections outside the cluster.
3. A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use * to bypass the proxy for all destinations.
4. If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace that contains one or more additional CA certificates that are required for proxying HTTPS connections. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges these contents with the Red Hat Enterprise Linux CoreOS (RHCOS) trust bundle, and this config map is referenced in the **trustedCA** field of the **Proxy** object. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.

NOTE

The installation program does not support the proxy **readinessEndpoints** field.

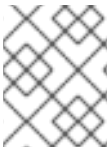
NOTE

If the installer times out, restart and then complete the deployment by using the **wait-for** command of the installer. For example:

```
$ ./openshift-install wait-for install-complete --log-level debug
```

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.



NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

16.2.9.4. Configuring a three-node cluster

Optionally, you can deploy zero compute machines in a minimal three node cluster that consists of three control plane machines only. This provides smaller, more resource efficient clusters for cluster administrators and developers to use for testing, development, and production.

In three-node OpenShift Container Platform environments, the three control plane machines are schedulable, which means that your application workloads are scheduled to run on them.

Prerequisites

- You have an existing **install-config.yaml** file.

Procedure

- Ensure that the number of compute replicas is set to **0** in your **install-config.yaml** file, as shown in the following **compute** stanza:

```
compute:
- name: worker
  platform: {}
  replicas: 0
```

NOTE

You must set the value of the **replicas** parameter for the compute machines to **0** when you install OpenShift Container Platform on user-provisioned infrastructure, regardless of the number of compute machines you are deploying. In installer-provisioned installations, the parameter controls the number of compute machines that the cluster creates and manages for you. This does not apply to user-provisioned installations, where the compute machines are deployed manually.

NOTE

The preferred resource for control plane nodes is six vCPUs and 21 GB. For three control plane nodes this is the memory + vCPU equivalent of a minimum five-node cluster. You should back the three nodes, each installed on a 120 GB disk, with three IFLs that are SMT2 enabled. The minimum tested setup is three vCPUs and 10 GB on a 120 GB disk for each control plane node.

For three-node cluster installations, follow these next steps:

- If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes. See the *Load balancing requirements for user-provisioned infrastructure* section for more information.

- When you create the Kubernetes manifest files in the following procedure, ensure that the **mastersSchedulable** parameter in the **<installation_directory>/manifests/cluster-scheduler-02-config.yml** file is set to **true**. This enables your application workloads to run on the control plane nodes.

- Do not deploy any compute nodes when you create the Red Hat Enterprise Linux CoreOS (RHCOS) machines.

16.2.10. Cluster Network Operator configuration

The configuration for the cluster network is specified as part of the Cluster Network Operator (CNO) configuration and stored in a custom resource (CR) object that is named **cluster**. The CR specifies the fields for the **Network** API in the **operator.openshift.io** API group.

The CNO configuration inherits the following fields during cluster installation from the **Network** API in the **Network.config.openshift.io** API group and these fields cannot be changed:

clusterNetwork

IP address pools from which pod IP addresses are allocated.

serviceNetwork

IP address pool for services.

defaultNetwork.type

Cluster network provider, such as OpenShift SDN or OVN-Kubernetes.

You can specify the cluster network provider configuration for your cluster by setting the fields for the **defaultNetwork** object in the CNO object named **cluster**.

16.2.10.1. Cluster Network Operator configuration object

The fields for the Cluster Network Operator (CNO) are described in the following table:

Table 16.12. Cluster Network Operator configuration object

Field	Type	Description
metadata.name	**string**	The name of the CNO object. This name is always **cluster**.
spec.clusterNetwork	**array**	A list specifying the blocks of IP addresses from which pod IP addresses are allocated and the subnet prefix length assigned to each individual node in the cluster. For example: `spec:` `  clusterNetwork:` `  - cidr: 10.128.0.0/19` `  hostPrefix: 23` `  - cidr: 10.128.32.0/19` `  hostPrefix: 23` You can customize this field only in the **install-config.yaml** file before you create the manifests. The value is read-only in the manifest file.

Field	Type	Description
spec.serviceNetwork	**array**	A block of IP addresses for services. The OpenShift SDN and OVN-Kubernetes Container Network Interface (CNI) network providers support only a single IP address block for the service network. For example: `spec:` `  serviceNetwork:` `  - 172.30.0.0/14` You can customize this field only in the **install-config.yaml** file before you create the manifests. The value is read-only in the manifest file.
spec.defaultNetwork	**object**	Configures the Container Network Interface (CNI) cluster network provider for the cluster network.
spec.kubeProxyConfig	**object**	The fields for this object specify the kube-proxy configuration. If you are using the OVN-Kubernetes cluster network provider, the kube-proxy configuration has no effect.

defaultNetwork object configuration

The values for the **defaultNetwork** object are defined in the following table:

Table 16.13. defaultNetwork object

Field	Type	Description
type	**string**	Either **OpenShiftSDN** or **OVNKubernetes**. The cluster network provider is selected during installation. This value cannot be changed after cluster installation.  **NOTE** OpenShift Container Platform uses the OpenShift SDN Container Network Interface (CNI) cluster network provider by default.
openshiftSDNConfig	**object**	This object is only valid for the OpenShift SDN cluster network provider.
ovnKubernetesConfig	**object**	This object is only valid for the OVN-Kubernetes cluster network provider.

Configuration for the OpenShift SDN CNI cluster network provider

The following table describes the configuration fields for the OpenShift SDN Container Network Interface (CNI) cluster network provider.

Table 16.14. openshiftSDNConfig object

Field	Type	Description
mode	**string**	Configures the network isolation mode for OpenShift SDN. The default value is **NetworkPolicy**. The values **Multitenant** and **Subnet** are available for backwards compatibility with OpenShift Container Platform 3.x but are not recommended. This value cannot be changed after cluster installation.
mtu	**integer**	The maximum transmission unit (MTU) for the VXLAN overlay network. This is detected automatically based on the MTU of the primary network interface. You do not normally need to override the detected MTU. If the auto-detected value is not what you expect it to be, confirm that the MTU on the primary network interface on your nodes is correct. You cannot use this option to change the MTU value of the primary network interface on the nodes. If your cluster requires different MTU values for different nodes, you must set this value to **50** less than the lowest MTU value in your cluster. For example, if some nodes in your cluster have an MTU of **9001**, and some have an MTU of**1500**, you must set this value to **1450**. This value cannot be changed after cluster installation.
vxlanPort	**integer**	The port to use for all VXLAN packets. The default value is **4789**. This value cannot be changed after cluster installation. If you are running in a virtualized environment with existing nodes that are part of another VXLAN network, then you might be required to change this. For example, when running an OpenShift SDN overlay on top of VMware NSX-T, you must select an alternate port for the VXLAN, because both SDNs use the same default VXLAN port number. On Amazon Web Services (AWS), you can select an alternate port for the VXLAN between port **9000** and port **9999**.

Example OpenShift SDN configuration

```
defaultNetwork:
  type: OpenShiftSDN
  openshiftSDNConfig:
    mode: NetworkPolicy
    mtu: 1450
    vxlanPort: 4789
```

Configuration for the OVN-Kubernetes CNI cluster network provider

The following table describes the configuration fields for the OVN-Kubernetes CNI cluster network provider.

Table 16.15. **ovnKubernetesConfig** object

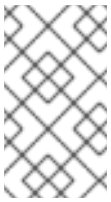
Field	Type	Description
mtu	**integer**	The maximum transmission unit (MTU) for the Geneve (Generic Network Virtualization Encapsulation) overlay network. This is detected automatically based on the MTU of the primary network interface. You do not normally need to override the detected MTU. If the auto-detected value is not what you expect it to be, confirm that the MTU on the primary network interface on your nodes is correct. You cannot use this option to change the MTU value of the primary network interface on the nodes. If your cluster requires different MTU values for different nodes, you must set this value to **100** less than the lowest MTU value in your cluster. For example, if some nodes in your cluster have an MTU of **9001**, and some have an MTU of**1500**, you must set this value to **1400**.
genevePort	**integer**	The port to use for all Geneve packets. The default value is **6081**. This value cannot be changed after cluster installation.
ipsecConfig	**object**	Specify an empty object to enable IPsec encryption.
policyAuditConfig	**object**	Specify a configuration object for customizing network policy audit logging. If unset, the defaults audit log settings are used.
gatewayConfig	**object**	Optional: Specify a configuration object for customizing how egress traffic is sent to the node gateway.  **NOTE** While migrating egress traffic, you can expect some disruption to workloads and service traffic until the Cluster Network Operator (CNO) successfully rolls out the changes.

Table 16.16. **policyAuditConfig** object

Field	Type	Description
rateLimit	integer	The maximum number of messages to generate every second per node. The default value is **20** messages per second.

Field	Type	Description
maxFileSize	integer	The maximum size for the audit log in bytes. The default value is **50000000** or 50 MB.
destination	string	One of the following additional audit log targets: **libc** The libc **syslog()** function of the journald process on the host. **udp:<host>:<port>** A syslog server. Replace **<host>:<port>** with the host and port of the syslog server. **unix:<file>** A Unix Domain Socket file specified by **<file>**. **null** Do not send the audit logs to any additional target.
syslogFacility	string	The syslog facility, such as **kern**, as defined by RFC5424. The default value is **local0**.

Table 16.17. **gatewayConfig** object

Field	Type	Description
routingViaHost	**boolean**	Set this field to **true** to send egress traffic from pods to the host networking stack. For highly-specialized installations and applications that rely on manually configured routes in the kernel routing table, you might want to route egress traffic to the host networking stack. By default, egress traffic is processed in OVN to exit the cluster and is not affected by specialized routes in the kernel routing table. The default value is **false**. This field has an interaction with the Open vSwitch hardware offloading feature. If you set this field to **true**, you do not receive the performance benefits of the offloading because egress traffic is processed by the host networking stack.

Example OVN-Kubernetes configuration with IPSec enabled

```
defaultNetwork:
  type: OVNKubernetes
  ovnKubernetesConfig:
    mtu: 1400
    genevePort: 6081
    ipsecConfig: {}
```

kubeProxyConfig object configuration
The values for the **kubeProxyConfig** object are defined in the following table:

Table 16.18. **kubeProxyConfig** object

Field	Type	Description
iptablesSyncPeriod	**string**	The refresh period for **iptables** rules. The default value is **30s**. Valid suffixes include **s**, **m**, and **h** and are described in the Go **time** package documentation. **NOTE** Because of performance improvements introduced in OpenShift Container Platform 4.3 and greater, adjusting the **iptablesSyncPeriod** parameter is no longer necessary.
proxyArguments.iptables-min-sync-period	**array**	The minimum duration before refreshing **iptables** rules. This field ensures that the refresh does not happen too frequently. Valid suffixes include **s**, **m**, and **h** and are described in the Go **time** package. The default value is: `kubeProxyConfig:` `  proxyArguments:` `  iptables-min-sync-period:` `  - 0s`

16.2.11. Creating the Kubernetes manifest and Ignition config files

Because you must modify some cluster definition files and manually start the cluster machines, you must generate the Kubernetes manifest and Ignition config files that the cluster needs to configure the machines.

The installation configuration file transforms into the Kubernetes manifests. The manifests wrap into the Ignition configuration files, which are later used to configure the cluster machines.

IMPORTANT

- The Ignition config files that the OpenShift Container Platform installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

NOTE

The installation program that generates the manifest and Ignition files is architecture specific and can be obtained from the client image mirror. The Linux version of the installation program runs on s390x only. This installer program is also available as a Mac OS version.

Prerequisites

- You obtained the OpenShift Container Platform installation program.
- You created the **install-config.yaml** installation configuration file.

Procedure

1. Change to the directory that contains the OpenShift Container Platform installation program and generate the Kubernetes manifests for the cluster:

```
$ ./openshift-install create manifests --dir <installation_directory> 1
```

1 For **<installation_directory>**, specify the installation directory that contains the **install-config.yaml** file you created.

WARNING

If you are installing a three-node cluster, skip the following step to allow the control plane nodes to be schedulable.

IMPORTANT

When you configure control plane nodes from the default unschedulable to schedulable, additional subscriptions are required. This is because control plane nodes then become compute nodes.

2. Check that the **mastersSchedulable** parameter in the **<installation_directory>/manifests/cluster-scheduler-02-config.yml** Kubernetes manifest file is set to **false**. This setting prevents pods from being scheduled on the control plane machines:
   a. Open the **<installation_directory>/manifests/cluster-scheduler-02-config.yml** file.
   b. Locate the **mastersSchedulable** parameter and ensure that it is set to **false**.
   c. Save and exit the file.
3. To create the Ignition configuration files, run the following command from the directory that contains the installation program:

```
$ ./openshift-install create ignition-configs --dir <installation_directory> 1
```

1 For **<installation_directory>**, specify the same installation directory.

Ignition config files are created for the bootstrap, control plane, and compute nodes in the installation directory. The **kubeadmin-password** and **kubeconfig** files are created in the **./<installation_directory>/auth** directory:

```
.
├── auth
│   ├── kubeadmin-password
│   └── kubeconfig
├── bootstrap.ign
├── master.ign
├── metadata.json
└── worker.ign
```

16.2.12. Installing RHCOS and starting the OpenShift Container Platform bootstrap process

To install OpenShift Container Platform on IBM Z infrastructure that you provision, you must install Red Hat Enterprise Linux CoreOS (RHCOS) on z/VM guest virtual machines. When you install RHCOS, you must provide the Ignition config file that was generated by the OpenShift Container Platform installation program for the type of machine you are installing. If you have configured suitable networking, DNS, and load balancing infrastructure, the OpenShift Container Platform bootstrap process begins automatically after the RHCOS z/VM guest virtual machines have rebooted.

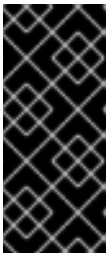
Complete the following steps to create the machines.

Prerequisites

- An HTTP or HTTPS server running on your provisioning machine that is accessible to the machines you create.

Procedure

1. Log in to Linux on your provisioning machine.
2. Obtain the Red Hat Enterprise Linux CoreOS (RHCOS) kernel, initramfs, and rootfs files from the RHCOS image mirror.



IMPORTANT

The RHCOS images might not change with every release of OpenShift Container Platform. You must download images with the highest version that is less than or equal to the OpenShift Container Platform version that you install. Only use the appropriate kernel, initramfs, and rootfs artifacts described in the following procedure.

The file names contain the OpenShift Container Platform version number. They resemble the following examples:

- kernel: **rhcos-<version>-live-kernel-<architecture>**
- initramfs: **rhcos-<version>-live-initramfs.<architecture>.img**

- rootfs: **rhcos-<version>-live-rootfs.<architecture>.img**

NOTE

The rootfs image is the same for FCP and DASD.

3. Create parameter files. The following parameters are specific for a particular virtual machine:

- For **ip=**, specify the following seven entries:

  i. The IP address for the machine.

  ii. An empty string.

  iii. The gateway.

  iv. The netmask.

  v. The machine host and domain name in the form **hostname.domainname**. Omit this value to let RHCOS decide.

  vi. The network interface name. Omit this value to let RHCOS decide.

  vii. If you use static IP addresses, specify **none**.

- For **coreos.inst.ignition_url=**, specify the Ignition file for the machine role. Use **bootstrap.ign**, **master.ign**, or **worker.ign**. Only HTTP and HTTPS protocols are supported.

- For **coreos.live.rootfs_url=**, specify the matching rootfs artifact for the kernel and initramfs you are booting. Only HTTP and HTTPS protocols are supported.

- For installations on DASD-type disks, complete the following tasks:

  i. For **coreos.inst.install_dev=**, specify **dasda**.

  ii. Use **rd.dasd=** to specify the DASD where RHCOS is to be installed.

  iii. Leave all other parameters unchanged.
  Example parameter file, **bootstrap-0.parm**, for the bootstrap machine:

```
rd.neednet=1 \
console=ttysclp0 \
coreos.inst.install_dev=dasda \
coreos.live.rootfs_url=http://cl1.provide.example.com:8080/assets/rhcos-live-
rootfs.s390x.img \
coreos.inst.ignition_url=http://cl1.provide.example.com:8080/ignition/bootstrap.ign \
ip=172.18.78.2::172.18.78.1:255.255.255.0:::none nameserver=172.18.78.1 \
rd.znet=qeth,0.0.bdf0,0.0.bdf1,0.0.bdf2,layer2=1,portno=0 \
zfcp.allow_lun_scan=0 \
rd.dasd=0.0.3490
```

  Write all options in the parameter file as a single line and make sure you have no newline characters.

- For installations on FCP-type disks, complete the following tasks:

  i. Use **rd.zfcp=<adapter>,<wwpn>,<lun>** to specify the FCP disk where RHCOS is to be

installed. For multipathing repeat this step for each additional path.

NOTE

When you install with multiple paths, you must enable multipathing directly after the installation, not at a later point in time, as this can cause problems.

ii. Set the install device as: **coreos.inst.install_dev=sda**.

NOTE

If additional LUNs are configured with NPIV, FCP requires **zfcp.allow_lun_scan=0**. If you must enable **zfcp.allow_lun_scan=1** because you use a CSI driver, for example, you must configure your NPIV so that each node cannot access the boot partition of another node.

iii. Leave all other parameters unchanged.

IMPORTANT

Additional postinstallation steps are required to fully enable multipathing. For more information, see "Enabling multipathing with kernel arguments on RHCOS" in *Post-installation machine configuration tasks*.

The following is an example parameter file **worker-1.parm** for a worker node with multipathing:

```
rd.neednet=1 \
console=ttysclp0 \
coreos.inst.install_dev=sda \
coreos.live.rootfs_url=http://cl1.provide.example.com:8080/assets/rhcos-live-rootfs.s390x.img \
coreos.inst.ignition_url=http://cl1.provide.example.com:8080/ignition/worker.ign \
ip=172.18.78.2::172.18.78.1:255.255.255.0:::none nameserver=172.18.78.1 \
rd.znet=qeth,0.0.bdf0,0.0.bdf1,0.0.bdf2,layer2=1,portno=0 \
zfcp.allow_lun_scan=0 \
rd.zfcp=0.0.1987,0x50050763070bc5e3,0x4008400B00000000 \
rd.zfcp=0.0.19C7,0x50050763070bc5e3,0x4008400B00000000 \
rd.zfcp=0.0.1987,0x50050763071bc5e3,0x4008400B00000000 \
rd.zfcp=0.0.19C7,0x50050763071bc5e3,0x4008400B00000000
```

Write all options in the parameter file as a single line and make sure you have no newline characters.

4. Transfer the initramfs, kernel, parameter files, and RHCOS images to z/VM, for example with FTP. For details about how to transfer the files with FTP and boot from the virtual reader, see Installing under Z/VM.

5. Punch the files to the virtual reader of the z/VM guest virtual machine that is to become your bootstrap node.
   See PUNCH in IBM Documentation.

TIP

You can use the CP PUNCH command or, if you use Linux, the **vmur** command to transfer files between two z/VM guest virtual machines.

6. Log in to CMS on the bootstrap machine.
7. IPL the bootstrap machine from the reader:

```
$ ipl c
```

See IPL in IBM Documentation.

8. Repeat this procedure for the other machines in the cluster.

16.2.12.1. Advanced RHCOS installation reference

This section illustrates the networking configuration and other advanced options that allow you to modify the Red Hat Enterprise Linux CoreOS (RHCOS) manual installation process. The following tables describe the kernel arguments and command-line options you can use with the RHCOS live installer and the **coreos-installer** command.

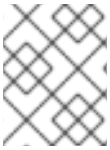
16.2.12.1.1. Networking and bonding options for ISO installations

If you install RHCOS from an ISO image, you can add kernel arguments manually when you boot the image to configure networking for a node. If no networking arguments are specified, DHCP is activated in the initramfs when RHCOS detects that networking is required to fetch the Ignition config file.

IMPORTANT

When adding networking arguments manually, you must also add the **rd.neednet=1** kernel argument to bring the network up in the initramfs.

The following information provides examples for configuring networking and bonding on your RHCOS nodes for ISO installations. The examples describe how to use the **ip=**, **nameserver=**, and **bond=** kernel arguments.



NOTE

Ordering is important when adding the kernel arguments: **ip=**, **nameserver=**, and then **bond=**.

The networking options are passed to the **dracut** tool during system boot. For more information about the networking options supported by **dracut**, see the **dracut.cmdline** manual page.

The following examples are the networking options for ISO installation.

Configuring DHCP or static IP addresses
To configure an IP address, either use DHCP (**ip=dhcp**) or set an individual static IP address (**ip=<host_ip>**). If setting a static IP, you must then identify the DNS server IP address (**nameserver=<dns_ip>**) on each node. The following example sets:

- The node's IP address to **10.10.10.2**

- The gateway address to **10.10.10.254**
- The netmask to **255.255.255.0**
- The hostname to **core0.example.com**
- The DNS server address to **4.4.4.41**
- The auto-configuration value to **none**. No auto-configuration is required when IP networking is configured statically.

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp1s0:none
nameserver=4.4.4.41
```

NOTE

When you use DHCP to configure IP addressing for the RHCOS machines, the machines also obtain the DNS server information through DHCP. For DHCP-based deployments, you can define the DNS server address that is used by the RHCOS nodes through your DHCP server configuration.

Configuring an IP address without a static hostname
You can configure an IP address without assigning a static hostname. If a static hostname is not set by the user, it will be picked up and automatically set by a reverse DNS lookup. To configure an IP address without a static hostname refer to the following example:

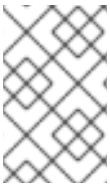
- The node's IP address to **10.10.10.2**
- The gateway address to **10.10.10.254**
- The netmask to **255.255.255.0**
- The DNS server address to **4.4.4.41**
- The auto-configuration value to **none**. No auto-configuration is required when IP networking is configured statically.

```
ip=10.10.10.2::10.10.10.254:255.255.255.0::enp1s0:none
nameserver=4.4.4.41
```

Specifying multiple network interfaces
You can specify multiple network interfaces by setting multiple **ip=** entries.

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp1s0:none
ip=10.10.10.3::10.10.10.254:255.255.255.0:core0.example.com:enp2s0:none
```

Configuring default gateway and route
Optional: You can configure routes to additional networks by setting an **rd.route=** value.



NOTE

When you configure one or multiple networks, one default gateway is required. If the additional network gateway is different from the primary network gateway, the default gateway must be the primary network gateway.

- Run the following command to configure the default gateway:

```
ip=::10.10.10.254::::
```

- Enter the following command to configure the route for the additional network:

```
rd.route=20.20.20.0/24:20.20.20.254:enp2s0
```

Disabling DHCP on a single interface
You can disable DHCP on a single interface, such as when there are two or more network interfaces and only one interface is being used. In the example, the **enp1s0** interface has a static networking configuration and DHCP is disabled for **enp2s0**, which is not used:

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp1s0:none
ip=::::core0.example.com:enp2s0:none
```

Combining DHCP and static IP configurations
You can combine DHCP and static IP configurations on systems with multiple network interfaces, for example:

```
ip=enp1s0:dhcp
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp2s0:none
```

Configuring VLANs on individual interfaces
Optional: You can configure VLANs on individual interfaces by using the **vlan=** parameter.

- To configure a VLAN on a network interface and use a static IP address, run the following command:

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp2s0.100:none
vlan=enp2s0.100:enp2s0
```

- To configure a VLAN on a network interface and to use DHCP, run the following command:

```
ip=enp2s0.100:dhcp
vlan=enp2s0.100:enp2s0
```

Providing multiple DNS servers
You can provide multiple DNS servers by adding a **nameserver=** entry for each server, for example:

```
nameserver=1.1.1.1
nameserver=8.8.8.8
```

Bonding multiple network interfaces to a single interface
Optional: You can bond multiple network interfaces to a single interface by using the **bond=** option. Refer to the following examples:

- The syntax for configuring a bonded interface is: **bond=name[:network_interfaces][:options]**
  name is the bonding device name (**bond0**), *network_interfaces* represents a comma-separated list of physical (ethernet) interfaces (**em1,em2**), and *options* is a comma-separated list of bonding options. Enter **modinfo bonding** to see available options.

- When you create a bonded interface using **bond=**, you must specify how the IP address is assigned and other information for the bonded interface.
- To configure the bonded interface to use DHCP, set the bond's IP address to **dhcp**. For example:

```
bond=bond0:em1,em2:mode=active-backup
ip=bond0:dhcp
```

- To configure the bonded interface to use a static IP address, enter the specific IP address you want and related information. For example:

```
bond=bond0:em1,em2:mode=active-backup,fail_over_mac=1
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:bond0:none
```

Always set option **fail_over_mac=1** in active-backup mode, to avoid problems when shared OSA/RoCE cards are used.

Bonding multiple network interfaces to a single interface
Optional: You can configure VLANs on bonded interfaces by using the **vlan=** parameter and to use DHCP, for example:

```
ip=bond0.100:dhcp
bond=bond0:em1,em2:mode=active-backup
vlan=bond0.100:bond0
```

Use the following example to configure the bonded interface with a VLAN and to use a static IP address:

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:bond0.100:none
bond=bond0:em1,em2:mode=active-backup
vlan=bond0.100:bond0
```

Using network teaming
Optional: You can use a network teaming as an alternative to bonding by using the **team=** parameter:

- The syntax for configuring a team interface is: **team=name[:network_interfaces]**
  name is the team device name (**team0**) and *network_interfaces* represents a comma-separated list of physical (ethernet) interfaces (**em1, em2**).

NOTE

Teaming is planned to be deprecated when RHCOS switches to an upcoming version of RHEL. For more information, see this Red Hat Knowledgebase Article .

Use the following example to configure a network team:

```
team=team0:em1,em2
ip=team0:dhcp
```

16.2.13. Waiting for the bootstrap process to complete

The OpenShift Container Platform bootstrap process begins after the cluster nodes first boot into the persistent RHCOS environment that has been installed to disk. The configuration information provided

through the Ignition config files is used to initialize the bootstrap process and install OpenShift Container Platform on the machines. You must wait for the bootstrap process to complete.

Prerequisites

- You have created the Ignition config files for your cluster.
- You have configured suitable network, DNS and load balancing infrastructure.
- You have obtained the installation program and generated the Ignition config files for your cluster.
- You installed RHCOS on your cluster machines and provided the Ignition config files that the OpenShift Container Platform installation program generated.
- Your machines have direct internet access or have an HTTP or HTTPS proxy available.

Procedure

1. Monitor the bootstrap process:

```
$ ./openshift-install --dir <installation_directory> wait-for bootstrap-complete \ 1
    --log-level=info 2
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

Example output

```
INFO Waiting up to 30m0s for the Kubernetes API at https://api.test.example.com:6443...
INFO API v1.24.0 up
INFO Waiting up to 30m0s for bootstrapping to complete...
INFO It is now safe to remove the bootstrap resources
```

The command succeeds when the Kubernetes API server signals that it has been bootstrapped on the control plane machines.

2. After the bootstrap process is complete, remove the bootstrap machine from the load balancer.

IMPORTANT

You must remove the bootstrap machine from the load balancer at this point. You can also remove or reformat the bootstrap machine itself.

16.2.14. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

Example output

```
system:admin
```

16.2.15. Approving the certificate signing requests for your machines

When you add machines to a cluster, two pending certificate signing requests (CSRs) are generated for each machine that you added. You must confirm that these CSRs are approved or, if necessary, approve them yourself. The client requests must be approved first, followed by the server requests.

Prerequisites

- You added machines to your cluster.

Procedure

1. Confirm that the cluster recognizes the machines:

```
$ oc get nodes
```

Example output

```
NAME      STATUS    ROLES   AGE  VERSION
master-0  Ready     master  63m  v1.24.0
master-1  Ready     master  63m  v1.24.0
master-2  Ready     master  64m  v1.24.0
```

The output lists all of the machines that you created.

NOTE

The preceding output might not include the compute nodes, also known as worker nodes, until some CSRs are approved.

2. Review the pending CSRs and ensure that you see the client requests with the **Pending** or **Approved** status for each machine that you added to the cluster:

```
$ oc get csr
```

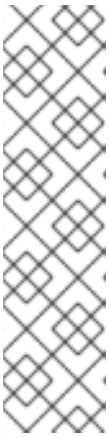
Example output

```
NAME        AGE   REQUESTOR                                 CONDITION
csr-mddf5   20m   system:node:master-01.example.com   Approved,Issued
csr-z5rln   16m   system:node:worker-21.example.com   Approved,Issued
```

3. If the CSRs were not approved, after all of the pending CSRs for the machines you added are in **Pending** status, approve the CSRs for your cluster machines:

NOTE

Because the CSRs rotate automatically, approve your CSRs within an hour of adding the machines to the cluster. If you do not approve them within an hour, the certificates will rotate, and more than two certificates will be present for each node. You must approve all of these certificates. After the client CSR is approved, the Kubelet creates a secondary CSR for the serving certificate, which requires manual approval. Then, subsequent serving certificate renewal requests are automatically approved by the **machine-approver** if the Kubelet requests a new certificate with identical parameters.



NOTE

For clusters running on platforms that are not machine API enabled, such as bare metal and other user-provisioned infrastructure, you must implement a method of automatically approving the kubelet serving certificate requests (CSRs). If a request is not approved, then the **oc exec**, **oc rsh**, and **oc logs** commands cannot succeed, because a serving certificate is required when the API server connects to the kubelet. Any operation that contacts the Kubelet endpoint requires this certificate approval to be in place. The method must watch for new CSRs, confirm that the CSR was submitted by the **node-bootstrapper** service account in the **system:node** or **system:admin** groups, and confirm the identity of the node.

- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

1 **<csr_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{{"\n"}}
{{end}}{{end}}' | xargs --no-run-if-empty oc adm certificate approve
```

NOTE

Some Operators might not become available until some CSRs are approved.

4. Now that your client requests are approved, you must review the server requests for each machine that you added to the cluster:

```
$ oc get csr
```

Example output

```
NAME        AGE     REQUESTOR                                                   CONDITION
csr-bfd72   5m26s   system:node:ip-10-0-50-126.us-east-2.compute.internal
Pending
csr-c57lv   5m26s   system:node:ip-10-0-95-157.us-east-2.compute.internal
Pending
...
```

5. If the remaining CSRs are not approved, and are in the **Pending** status, approve the CSRs for your cluster machines:

- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

1 **<csr_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{{"\n"}}
{{end}}{{end}}' | xargs oc adm certificate approve
```

6. After all client and server CSRs have been approved, the machines have the **Ready** status. Verify this by running the following command:

```
$ oc get nodes
```

Example output

```
NAME      STATUS    ROLES   AGE  VERSION
master-0  Ready     master  73m  v1.24.0
master-1  Ready     master  73m  v1.24.0
master-2  Ready     master  74m  v1.24.0
worker-0  Ready     worker  11m  v1.24.0
worker-1  Ready     worker  11m  v1.24.0
```

NOTE

It can take a few minutes after approval of the server CSRs for the machines to transition to the **Ready** status.

Additional information

- For more information on CSRs, see Certificate Signing Requests.

16.2.16. Initial Operator configuration

After the control plane initializes, you must immediately configure some Operators so that they all become available.

Prerequisites

- Your control plane has initialized.

Procedure

1. Watch the cluster components come online:

```
$ watch -n5 oc get clusteroperators
```

Example output

```
NAME                                       VERSION   AVAILABLE   PROGRESSING   DEGRADED
SINCE
authentication                             4.11.0    True        False         False      19m
baremetal                                  4.11.0    True        False         False      37m
cloud-credential                           4.11.0    True        False         False      40m
cluster-autoscaler                         4.11.0    True        False         False      37m
config-operator                            4.11.0    True        False         False      38m
console                                    4.11.0    True        False         False      26m
csi-snapshot-controller                    4.11.0    True        False         False      37m
dns                                        4.11.0    True        False         False      37m
etcd                                       4.11.0    True        False         False      36m
image-registry                             4.11.0    True        False         False      31m
ingress                                    4.11.0    True        False         False      30m
insights                                   4.11.0    True        False         False      31m
kube-apiserver                             4.11.0    True        False         False      26m
kube-controller-manager                    4.11.0    True        False         False      36m
kube-scheduler                             4.11.0    True        False         False      36m
kube-storage-version-migrator              4.11.0    True        False         False      37m
machine-api                                4.11.0    True        False         False      29m
machine-approver                           4.11.0    True        False         False      37m
machine-config                             4.11.0    True        False         False      36m
marketplace                                4.11.0    True        False         False      37m
monitoring                                 4.11.0    True        False         False      29m
network                                    4.11.0    True        False         False      38m
node-tuning                                4.11.0    True        False         False      37m
openshift-apiserver                        4.11.0    True        False         False      32m
openshift-controller-manager               4.11.0    True        False         False      30m
openshift-samples                          4.11.0    True        False         False      32m
```

```
operator-lifecycle-manager                 4.11.0    True        False         False      37m
operator-lifecycle-manager-catalog         4.11.0    True        False         False      37m
operator-lifecycle-manager-packageserver   4.11.0    True        False         False      32m
service-ca                                 4.11.0    True        False         False      38m
storage                                    4.11.0    True        False         False      37m
```

2. Configure the Operators that are not available.

16.2.16.1. Image registry storage configuration

The Image Registry Operator is not initially available for platforms that do not provide default storage. After installation, you must configure your registry to use storage so that the Registry Operator is made available.

Instructions are shown for configuring a persistent volume, which is required for production clusters. Where applicable, instructions are shown for configuring an empty directory as the storage location, which is available for only non-production clusters.

Additional instructions are provided for allowing the image registry to use block storage types by using the **Recreate** rollout strategy during upgrades.

16.2.16.1.1. Configuring registry storage for IBM Z

As a cluster administrator, following installation you must configure your registry to use storage.

Prerequisites

- You have access to the cluster as a user with the **cluster-admin** role.
- You have a cluster on IBM Z.
- You have provisioned persistent storage for your cluster, such as Red Hat OpenShift Data Foundation.

IMPORTANT

OpenShift Container Platform supports **ReadWriteOnce** access for image registry storage when you have only one replica. **ReadWriteOnce** access also requires that the registry uses the **Recreate** rollout strategy. To deploy an image registry that supports high availability with two or more replicas, **ReadWriteMany** access is required.

- Must have 100Gi capacity.

Procedure

1. To configure your registry to use storage, change the **spec.storage.pvc** in the **configs.imageregistry/cluster** resource.

NOTE

When you use shared storage, review your security settings to prevent outside access.

2. Verify that you do not have a registry pod:

```
$ oc get pod -n openshift-image-registry -l docker-registry=default
```

Example output

```
No resourses found in openshift-image-registry namespace
```

NOTE

If you do have a registry pod in your output, you do not need to continue with this procedure.

3. Check the registry configuration:

```
$ oc edit configs.imageregistry.operator.openshift.io
```

Example output

```
storage:
  pvc:
    claim:
```

Leave the **claim** field blank to allow the automatic creation of an **image-registry-storage** PVC.

4. Check the **clusteroperator** status:

```
$ oc get clusteroperator image-registry
```

Example output

```
NAME              VERSION        AVAILABLE   PROGRESSING   DEGRADED   SINCE
MESSAGE
image-registry    4.11           True        False         False      6h50m
```

5. Ensure that your registry is set to managed to enable building and pushing of images.

- Run:

```
$ oc edit configs.imageregistry/cluster
```

Then, change the line

```
managementState: Removed
```

to

```
managementState: Managed
```

16.2.16.1.2. Configuring storage for the image registry in non-production clusters

You must configure storage for the Image Registry Operator. For non-production clusters, you can set the image registry to an empty directory. If you do so, all images are lost if you restart the registry.

Procedure

- To set the image registry storage to an empty directory:

```
$ oc patch configs.imageregistry.operator.openshift.io cluster --type merge --patch '{"spec":{"storage":{"emptyDir":{}}}}'
```

WARNING

Configure this option for only non-production clusters.

If you run this command before the Image Registry Operator initializes its components, the **oc patch** command fails with the following error:

```
Error from server (NotFound): configs.imageregistry.operator.openshift.io "cluster" not found
```

Wait a few minutes and run the command again.

16.2.17. Completing installation on user-provisioned infrastructure

After you complete the Operator configuration, you can finish installing the cluster on infrastructure that you provide.

Prerequisites

- Your control plane has initialized.
- You have completed the initial Operator configuration.

Procedure

1. Confirm that all the cluster components are online with the following command:

```
$ watch -n5 oc get clusteroperators
```

Example output

```
NAME                                       VERSION   AVAILABLE   PROGRESSING   DEGRADED
SINCE
authentication                              4.11.0    True        False         False      19m
baremetal                                  4.11.0    True        False         False      37m
cloud-credential                            4.11.0    True        False         False      40m
cluster-autoscaler                          4.11.0    True        False         False      37m
config-operator                             4.11.0    True        False         False      38m
console                                    4.11.0    True        False         False      26m
```

```
csi-snapshot-controller                 4.11.0    True        False         False      37m
dns                                     4.11.0    True        False         False      37m
etcd                                    4.11.0    True        False         False      36m
image-registry                          4.11.0    True        False         False      31m
ingress                                 4.11.0    True        False         False      30m
insights                                4.11.0    True        False         False      31m
kube-apiserver                          4.11.0    True        False         False      26m
kube-controller-manager                 4.11.0    True        False         False      36m
kube-scheduler                          4.11.0    True        False         False      36m
kube-storage-version-migrator           4.11.0    True        False         False      37m
machine-api                             4.11.0    True        False         False      29m
machine-approver                        4.11.0    True        False         False      37m
machine-config                          4.11.0    True        False         False      36m
marketplace                             4.11.0    True        False         False      37m
monitoring                              4.11.0    True        False         False      29m
network                                 4.11.0    True        False         False      38m
node-tuning                             4.11.0    True        False         False      37m
openshift-apiserver                     4.11.0    True        False         False      32m
openshift-controller-manager            4.11.0    True        False         False      30m
openshift-samples                       4.11.0    True        False         False      32m
operator-lifecycle-manager              4.11.0    True        False         False      37m
operator-lifecycle-manager-catalog      4.11.0    True        False         False      37m
operator-lifecycle-manager-packageserver 4.11.0   True        False         False      32m
service-ca                              4.11.0    True        False         False      38m
storage                                 4.11.0    True        False         False      37m
```

Alternatively, the following command notifies you when all of the clusters are available. It also retrieves and displays credentials:

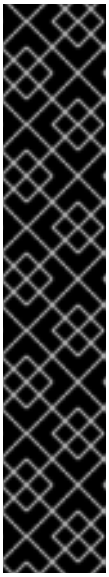
```
$ ./openshift-install --dir <installation_directory> wait-for install-complete 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

Example output

```
INFO Waiting up to 30m0s for the cluster to initialize...
```

The command succeeds when the Cluster Version Operator finishes deploying the OpenShift Container Platform cluster from Kubernetes API server.



IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

2. Confirm that the Kubernetes API server is communicating with the pods.

   a. To view a list of all pods, use the following command:

   ```
   $ oc get pods --all-namespaces
   ```

   Example output

   ```
   NAMESPACE                       NAME                                        READY   STATUS
   RESTARTS   AGE
   openshift-apiserver-operator    openshift-apiserver-operator-85cb746d55-zqhs8   1/1
   Running    1          9m
   openshift-apiserver             apiserver-67b9g                               1/1     Running     0
   3m
   openshift-apiserver             apiserver-ljcmx                               1/1     Running     0
   1m
   openshift-apiserver             apiserver-z25h4                               1/1     Running     0
   2m
   openshift-authentication-operator authentication-operator-69d5d8bf84-vh2n8        1/1
   Running    0          5m
   ...
   ```

   b. View the logs for a pod that is listed in the output of the previous command by using the following command:

   ```
   $ oc logs <pod_name> -n <namespace> 1
   ```

   1 Specify the pod name and namespace, as shown in the output of the previous command.

   If the pod logs display, the Kubernetes API server can communicate with the cluster machines.

3. For an installation with Fibre Channel Protocol (FCP), additional steps are required to enable multipathing. Do not enable multipathing during installation.
   See "Enabling multipathing with kernel arguments on RHCOS" in the *Post-installation machine configuration tasks* documentation for more information.

16.2.18. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.11, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to OpenShift Cluster Manager Hybrid Cloud Console.

After you confirm that your OpenShift Cluster Manager Hybrid Cloud Console inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, use subscription watch to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

Additional resources

- See About remote health monitoring for more information about the Telemetry service
- How to generate SOSREPORT within OpenShift4 nodes without SSH .

16.2.19. Next steps

- Enabling multipathing with kernel arguments on RHCOS .
- Customize your cluster.
- If necessary, you can opt out of remote health reporting .

16.3. INSTALLING A CLUSTER WITH Z/VM ON IBM Z AND LINUXONE IN A RESTRICTED NETWORK

In OpenShift Container Platform version 4.11, you can install a cluster on IBM Z and LinuxONE infrastructure that you provision in a restricted network.

NOTE

While this document refers to only IBM Z, all information in it also applies to LinuxONE.

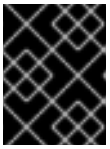
IMPORTANT

Additional considerations exist for non-bare metal platforms. Review the information in the guidelines for deploying OpenShift Container Platform on non-tested platforms before you install an OpenShift Container Platform cluster.

16.3.1. Prerequisites

- You reviewed details about the OpenShift Container Platform installation and update processes.
- You read the documentation on selecting a cluster installation method and preparing it for users.
- You created a mirror registry for installation in a restricted network and obtained the **imageContentSources** data for your version of OpenShift Container Platform.

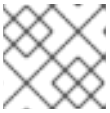
- Before you begin the installation process, you must move or remove any existing installation files. This ensures that the required installation files are created and updated during the installation process.



IMPORTANT

Ensure that installation steps are done from a machine with access to the installation media.

- You provisioned persistent storage using OpenShift Data Foundation or other supported storage protocols for your cluster. To deploy a private image registry, you must set up persistent storage with **ReadWriteMany** access.
- If you use a firewall and plan to use the Telemetry service, you configured the firewall to allow the sites that your cluster requires access to.



NOTE

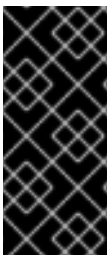
Be sure to also review this site list if you are configuring a proxy.

16.3.2. About installations in restricted networks

In OpenShift Container Platform 4.11, you can perform an installation that does not require an active connection to the internet to obtain software components. Restricted network installations can be completed using installer-provisioned infrastructure or user-provisioned infrastructure, depending on the cloud platform to which you are installing the cluster.

If you choose to perform a restricted network installation on a cloud platform, you still require access to its cloud APIs. Some cloud functions, like Amazon Web Service's Route 53 DNS and IAM services, require internet access. Depending on your network, you might require less internet access for an installation on bare metal hardware or on VMware vSphere.

To complete a restricted network installation, you must create a registry that mirrors the contents of the OpenShift image registry and contains the installation media. You can create this registry on a mirror host, which can access both the internet and your closed network, or by using other methods that meet your restrictions.



IMPORTANT

Because of the complexity of the configuration for user-provisioned installations, consider completing a standard user-provisioned infrastructure installation before you attempt a restricted network installation using user-provisioned infrastructure. Completing this test installation might make it easier to isolate and troubleshoot any issues that might arise during your installation in a restricted network.

16.3.2.1. Additional limits

Clusters in restricted networks have the following additional limitations and restrictions:

- The **ClusterVersion** status includes an **Unable to retrieve available updates** error.
- By default, you cannot use the contents of the Developer Catalog because you cannot access the required image stream tags.

16.3.3. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.11, you require access to the internet to obtain the images that are necessary to install your cluster.

You must have internet access to:

- Access OpenShift Cluster Manager Hybrid Cloud Console to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access Quay.io to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.

IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

16.3.4. Requirements for a cluster with user-provisioned infrastructure

For a cluster that contains user-provisioned infrastructure, you must deploy all of the required machines.

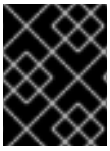
This section describes the requirements for deploying OpenShift Container Platform on user-provisioned infrastructure.

16.3.4.1. Required machines for cluster installation

The smallest OpenShift Container Platform clusters require the following hosts:

Table 16.19. Minimum required hosts

Hosts	Description
One temporary bootstrap machine	The cluster requires the bootstrap machine to deploy the OpenShift Container Platform cluster on the three control plane machines. You can remove the bootstrap machine after you install the cluster.
Three control plane machines	The control plane machines run the Kubernetes and OpenShift Container Platform services that form the control plane.
At least two compute machines, which are also known as worker machines.	The workloads requested by OpenShift Container Platform users run on the compute machines.



IMPORTANT

To improve high availability of your cluster, distribute the control plane machines over different z/VM instances on at least two physical machines.

The bootstrap, control plane, and compute machines must use Red Hat Enterprise Linux CoreOS (RHCOS) as the operating system.

Note that RHCOS is based on Red Hat Enterprise Linux (RHEL) 8 and inherits all of its hardware certifications and requirements. See Red Hat Enterprise Linux technology capabilities and limits .

16.3.4.2. Minimum resource requirements for cluster installation

Each cluster machine must meet the following minimum requirements:

Table 16.20. Minimum resource requirements

Machine	Operating System	vCPU [1]	Virtual RAM	Storage	IOPS
Bootstrap	RHCOS	4	16 GB	100 GB	N/A
Control plane	RHCOS	4	16 GB	100 GB	N/A
Compute	RHCOS	2	8 GB	100 GB	N/A

1. One physical core (IFL) provides two logical cores (threads) when SMT-2 is enabled. The hypervisor can provide two or more vCPUs.

If an instance type for your platform meets the minimum requirements for cluster machines, it is supported to use in OpenShift Container Platform.

Additional resources

- Optimizing storage

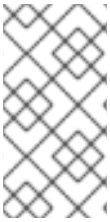
16.3.4.3. Minimum IBM Z system environment

You can install OpenShift Container Platform version 4.11 on the following IBM hardware:

- IBM z16 (all models), IBM z15 (all models), IBM z14 (all models), IBM z13, and IBM z13s
- LinuxONE, any version

Hardware requirements

- The equivalent of six Integrated Facilities for Linux (IFL), which are SMT2 enabled, for each cluster.
- At least one network connection to both connect to the **LoadBalancer** service and to serve data for traffic outside the cluster.



NOTE

You can use dedicated or shared IFLs to assign sufficient compute resources. Resource sharing is one of the key strengths of IBM Z. However, you must adjust capacity correctly on each hypervisor layer and ensure sufficient resources for every OpenShift Container Platform cluster.

IMPORTANT

Since the overall performance of the cluster can be impacted, the LPARs that are used to setup the OpenShift Container Platform clusters must provide sufficient compute capacity. In this context, LPAR weight management, entitlements, and CPU shares on the hypervisor level play an important role.

Operating system requirements

- One instance of z/VM 7.2 or later

On your z/VM instance, set up:

- Three guest virtual machines for OpenShift Container Platform control plane machines
- Two guest virtual machines for OpenShift Container Platform compute machines
- One guest virtual machine for the temporary OpenShift Container Platform bootstrap machine

IBM Z network connectivity requirements
To install on IBM Z under z/VM, you require a single z/VM virtual NIC in layer 2 mode. You also need:

- A direct-attached OSA or RoCE network adapter
- A z/VM VSwitch set up. For a preferred setup, use OSA link aggregation.

Disk storage for the z/VM guest virtual machines

- FICON attached disk storage (DASDs). These can be z/VM minidisks, fullpack minidisks, or dedicated DASDs, all of which must be formatted as CDL, which is the default. To reach the minimum required DASD size for Red Hat Enterprise Linux CoreOS (RHCOS) installations, you need extended address volumes (EAV). If available, use HyperPAV to ensure optimal performance.
- FCP attached disk storage

Storage / Main Memory

- 16 GB for OpenShift Container Platform control plane machines
- 8 GB for OpenShift Container Platform compute machines
- 16 GB for the temporary OpenShift Container Platform bootstrap machine

16.3.4.4. Preferred IBM Z system environment

Hardware requirements

- Three LPARS that each have the equivalent of six IFLs, which are SMT2 enabled, for each cluster.

- Two network connections to both connect to the **LoadBalancer** service and to serve data for traffic outside the cluster.
- HiperSockets, which are attached to a node either directly as a device or by bridging with one z/VM VSWITCH to be transparent to the z/VM guest. To directly connect HiperSockets to a node, you must set up a gateway to the external network via a RHEL 8 guest to bridge to the HiperSockets network.

Operating system requirements

- Two or three instances of z/VM 7.2 or later for high availability

On your z/VM instances, set up:

- Three guest virtual machines for OpenShift Container Platform control plane machines, one per z/VM instance.
- At least six guest virtual machines for OpenShift Container Platform compute machines, distributed across the z/VM instances.
- One guest virtual machine for the temporary OpenShift Container Platform bootstrap machine.
- To ensure the availability of integral components in an overcommitted environment, increase the priority of the control plane by using the CP command **SET SHARE**. Do the same for infrastructure nodes, if they exist. See SET SHARE in IBM Documentation.

IBM Z network connectivity requirements
To install on IBM Z under z/VM, you require a single z/VM virtual NIC in layer 2 mode. You also need:

- A direct-attached OSA or RoCE network adapter
- A z/VM VSwitch set up. For a preferred setup, use OSA link aggregation.

Disk storage for the z/VM guest virtual machines

- FICON attached disk storage (DASDs). These can be z/VM minidisks, fullpack minidisks, or dedicated DASDs, all of which must be formatted as CDL, which is the default. To reach the minimum required DASD size for Red Hat Enterprise Linux CoreOS (RHCOS) installations, you need extended address volumes (EAV). If available, use HyperPAV and High Performance FICON (zHPF) to ensure optimal performance.
- FCP attached disk storage

Storage / Main Memory

- 16 GB for OpenShift Container Platform control plane machines
- 8 GB for OpenShift Container Platform compute machines
- 16 GB for the temporary OpenShift Container Platform bootstrap machine

16.3.4.5. Certificate signing requests management

Because your cluster has limited access to automatic machine management when you use infrastructure that you provision, you must provide a mechanism for approving cluster certificate signing requests (CSRs) after installation. The **kube-controller-manager** only approves the kubelet client CSRs. The **machine-approver** cannot guarantee the validity of a serving certificate that is requested by using

kubelet credentials because it cannot confirm that the correct machine issued the request. You must determine and implement a method of verifying the validity of the kubelet serving certificate requests and approving them.

Additional resources

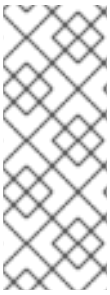
- See Bridging a HiperSockets LAN with a z/VM Virtual Switch in IBM Documentation.
- See Scaling HyperPAV alias devices on Linux guests on z/VM for performance optimization.
- See Topics in LPAR performance for LPAR weight management and entitlements.
- Recommended host practices for IBM Z & LinuxONE environments

16.3.4.6. Networking requirements for user-provisioned infrastructure

All the Red Hat Enterprise Linux CoreOS (RHCOS) machines require networking to be configured in **initramfs** during boot to fetch their Ignition config files.

During the initial boot, the machines require an IP address configuration that is set either through a DHCP server or statically by providing the required boot options. After a network connection is established, the machines download their Ignition config files from an HTTP or HTTPS server. The Ignition config files are then used to set the exact state of each machine. The Machine Config Operator completes more changes to the machines, such as the application of new certificates or keys, after installation.

It is recommended to use a DHCP server for long-term management of the cluster machines. Ensure that the DHCP server is configured to provide persistent IP addresses, DNS server information, and hostnames to the cluster machines.



NOTE

If a DHCP service is not available for your user-provisioned infrastructure, you can instead provide the IP networking configuration and the address of the DNS server to the nodes at RHCOS install time. These can be passed as boot arguments if you are installing from an ISO image. See the *Installing RHCOS and starting the OpenShift Container Platform bootstrap process* section for more information about static IP provisioning and advanced networking options.

The Kubernetes API server must be able to resolve the node names of the cluster machines. If the API servers and worker nodes are in different zones, you can configure a default DNS search zone to allow the API server to resolve the node names. Another supported approach is to always refer to hosts by their fully-qualified domain names in both the node objects and all DNS requests.

16.3.4.6.1. Setting the cluster node hostnames through DHCP

On Red Hat Enterprise Linux CoreOS (RHCOS) machines, the hostname is set through NetworkManager. By default, the machines obtain their hostname through DHCP. If the hostname is not provided by DHCP, set statically through kernel arguments, or another method, it is obtained through a reverse DNS lookup. Reverse DNS lookup occurs after the network has been initialized on a node and can take time to resolve. Other system services can start prior to this and detect the hostname as **localhost** or similar. You can avoid this by using DHCP to provide the hostname for each cluster node.

Additionally, setting the hostnames through DHCP can bypass any manual DNS record name configuration errors in environments that have a DNS split-horizon implementation.

16.3.4.6.2. Network connectivity requirements

You must configure the network connectivity between machines to allow OpenShift Container Platform cluster components to communicate. Each machine must be able to resolve the hostnames of all other machines in the cluster.

This section provides details about the ports that are required.

Table 16.21. Ports used for all-machine to all-machine communications

Protocol	Port	Description
ICMP	N/A	Network reachability tests
TCP	**1936**	Metrics
	9000-**9999**	Host level services, including the node exporter on ports **9100**-**9101** and the Cluster Version Operator on port**9099**.
	10250-**10259**	The default ports that Kubernetes reserves
	10256	openshift-sdn
UDP	**4789**	VXLAN
	6081	Geneve
	9000-**9999**	Host level services, including the node exporter on ports **9100**-**9101**.
	500	IPsec IKE packets
	4500	IPsec NAT-T packets
TCP/UDP	**30000**-**32767**	Kubernetes node port
ESP	N/A	IPsec Encapsulating Security Payload (ESP)

Table 16.22. Ports used for all-machine to control plane communications

Protocol	Port	Description
TCP	**6443**	Kubernetes API

Table 16.23. Ports used for control plane machine to control plane machine communications

Protocol	Port	Description
TCP	**2379-2380**	etcd server and peer ports

NTP configuration for user-provisioned infrastructure
OpenShift Container Platform clusters are configured to use a public Network Time Protocol (NTP) server by default. If you want to use a local enterprise NTP server, or if your cluster is being deployed in a disconnected network, you can configure the cluster to use a specific time server. For more information, see the documentation for *Configuring chrony time service* .

Additional resources

- Configuring chrony time service

16.3.4.7. User-provisioned DNS requirements

In OpenShift Container Platform deployments, DNS name resolution is required for the following components:

- The Kubernetes API
- The OpenShift Container Platform application wildcard
- The bootstrap, control plane, and compute machines

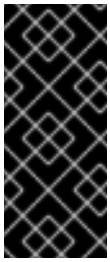
Reverse DNS resolution is also required for the Kubernetes API, the bootstrap machine, the control plane machines, and the compute machines.

DNS A/AAAA or CNAME records are used for name resolution and PTR records are used for reverse name resolution. The reverse records are important because Red Hat Enterprise Linux CoreOS (RHCOS) uses the reverse records to set the hostnames for all the nodes, unless the hostnames are provided by DHCP. Additionally, the reverse records are used to generate the certificate signing requests (CSR) that OpenShift Container Platform needs to operate.

The following DNS records are required for a user-provisioned OpenShift Container Platform cluster and they must be in place before installation. In each record, **<cluster_name>** is the cluster name and **<base_domain>** is the base domain that you specify in the **install-config.yaml** file. A complete DNS record takes the form: **<component>.<cluster_name>.<base_domain>.**.

Table 16.24. Required DNS records

Component	Record	Description
Kubernetes API	**api.<cluster_name>.<base_domain>.**	A DNS A/AAAA or CNAME record, and a DNS PTR record, to identify the API load balancer. These records must be resolvable by both clients external to the cluster and from all the nodes within the cluster.

Component	Record	Description
	api-int.<cluster_name>.<base_domain>.	A DNS A/AAAA or CNAME record, and a DNS PTR record, to internally identify the API load balancer. These records must be resolvable from all the nodes within the cluster.  **IMPORTANT** The API server must be able to resolve the worker nodes by the hostnames that are recorded in Kubernetes. If the API server cannot resolve the node names, then proxied API calls can fail, and you cannot retrieve logs from pods.
Routes	***.apps.<cluster_name>.<base_domain>.**	A wildcard DNS A/AAAA or CNAME record that refers to the application ingress load balancer. The application ingress load balancer targets the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default. These records must be resolvable by both clients external to the cluster and from all the nodes within the cluster. For example, **console-openshift-console.apps.<cluster_name>.<base_domain>** is used as a wildcard route to the OpenShift Container Platform console.
Bootstrap machine	**bootstrap.<cluster_name>.<base_domain>.**	A DNS A/AAAA or CNAME record, and a DNS PTR record, to identify the bootstrap machine. These records must be resolvable by the nodes within the cluster.
Control plane machines	**<master><n>.<cluster_name>.<base_domain>.**	DNS A/AAAA or CNAME records and DNS PTR records to identify each machine for the control plane nodes. These records must be resolvable by the nodes within the cluster.
Compute machines	**<worker><n>.<cluster_name>.<base_domain>.**	DNS A/AAAA or CNAME records and DNS PTR records to identify each machine for the worker nodes. These records must be resolvable by the nodes within the cluster.

NOTE

In OpenShift Container Platform 4.4 and later, you do not need to specify etcd host and SRV records in your DNS configuration.

TIP

You can use the **dig** command to verify name and reverse name resolution. See the section on *Validating DNS resolution for user-provisioned infrastructure* for detailed validation steps.

16.3.4.7.1. Example DNS configuration for user-provisioned clusters

This section provides A and PTR record configuration samples that meet the DNS requirements for deploying OpenShift Container Platform on user-provisioned infrastructure. The samples are not meant to provide advice for choosing one DNS solution over another.

In the examples, the cluster name is **ocp4** and the base domain is **example.com**.

Example DNS A record configuration for a user-provisioned cluster

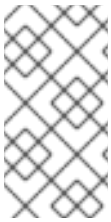
The following example is a BIND zone file that shows sample A records for name resolution in a user-provisioned cluster.

Example 16.4. Sample DNS zone database

```
$TTL 1W
@ IN SOA ns1.example.com. root (
  2019070700 ; serial
  3H  ; refresh (3 hours)
  30M  ; retry (30 minutes)
  2W  ; expiry (2 weeks)
  1W )  ; minimum (1 week)
 IN NS ns1.example.com.
 IN MX 10 smtp.example.com.
;
;
ns1.example.com.  IN A 192.168.1.5
smtp.example.com.  IN A 192.168.1.5
;
helper.example.com.  IN A 192.168.1.5
helper.ocp4.example.com. IN A 192.168.1.5
;
api.ocp4.example.com.  IN A 192.168.1.5 1
api-int.ocp4.example.com. IN A 192.168.1.5 2
;
*.apps.ocp4.example.com. IN A 192.168.1.5 3
;
bootstrap.ocp4.example.com. IN A 192.168.1.96 4
;
master0.ocp4.example.com. IN A 192.168.1.97 5
master1.ocp4.example.com. IN A 192.168.1.98 6
master2.ocp4.example.com. IN A 192.168.1.99 7
;
worker0.ocp4.example.com. IN A 192.168.1.11 8
worker1.ocp4.example.com. IN A 192.168.1.7 9
;
;EOF
```

1. Provides name resolution for the Kubernetes API. The record refers to the IP address of the API load balancer.
2. Provides name resolution for the Kubernetes API. The record refers to the IP address of the API load balancer and is used for internal cluster communications.
3. Provides name resolution for the wildcard routes. The record refers to the IP address of the application ingress load balancer. The application ingress load balancer targets the machines

application ingress load balancer. The application ingress load balancer targets the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.



NOTE

In the example, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

4 Provides name resolution for the bootstrap machine.

5 6 7 Provides name resolution for the control plane machines.

8 9 Provides name resolution for the compute machines.

Example DNS PTR record configuration for a user-provisioned cluster

The following example BIND zone file shows sample PTR records for reverse name resolution in a user-provisioned cluster.

Example 16.5. Sample DNS zone database for reverse records

```
$TTL 1W
@ IN SOA ns1.example.com. root (
  2019070700 ; serial
  3H  ; refresh (3 hours)
  30M  ; retry (30 minutes)
  2W  ; expiry (2 weeks)
  1W )  ; minimum (1 week)
 IN NS ns1.example.com.
;
5.1.168.192.in-addr.arpa. IN PTR api.ocp4.example.com. 1
5.1.168.192.in-addr.arpa. IN PTR api-int.ocp4.example.com. 2
;
96.1.168.192.in-addr.arpa. IN PTR bootstrap.ocp4.example.com. 3
;
97.1.168.192.in-addr.arpa. IN PTR master0.ocp4.example.com. 4
98.1.168.192.in-addr.arpa. IN PTR master1.ocp4.example.com. 5
99.1.168.192.in-addr.arpa. IN PTR master2.ocp4.example.com. 6
;
11.1.168.192.in-addr.arpa. IN PTR worker0.ocp4.example.com. 7
7.1.168.192.in-addr.arpa. IN PTR worker1.ocp4.example.com. 8
;
;EOF
```

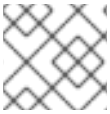
1 Provides reverse DNS resolution for the Kubernetes API. The PTR record refers to the record name of the API load balancer.

2 Provides reverse DNS resolution for the Kubernetes API. The PTR record refers to the record name of the API load balancer and is used for internal cluster communications.

3 Provides reverse DNS resolution for the bootstrap machine.

4 5 6 Provides reverse DNS resolution for the control plane machines.

7 8 Provides reverse DNS resolution for the compute machines.

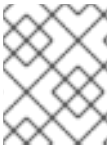


NOTE

A PTR record is not required for the OpenShift Container Platform application wildcard.

16.3.4.8. Load balancing requirements for user-provisioned infrastructure

Before you install OpenShift Container Platform, you must provision the API and application ingress load balancing infrastructure. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.



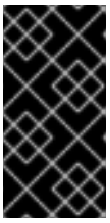
NOTE

If you want to deploy the API and application Ingress load balancers with a Red Hat Enterprise Linux (RHEL) instance, you must purchase the RHEL subscription separately.

The load balancing infrastructure must meet the following requirements:

1. **API load balancer**: Provides a common endpoint for users, both human and machine, to interact with and configure the platform. Configure the following conditions:

   - Layer 4 load balancing only. This can be referred to as Raw TCP, SSL Passthrough, or SSL Bridge mode. If you use SSL Bridge mode, you must enable Server Name Indication (SNI) for the API routes.
   - A stateless load balancing algorithm. The options vary based on the load balancer implementation.



IMPORTANT

Do not configure session persistence for an API load balancer. Configuring session persistence for a Kubernetes API server might cause performance issues from excess application traffic for your OpenShift Container Platform cluster and the Kubernetes API that runs inside the cluster.

Configure the following ports on both the front and back of the load balancers:

Table 16.25. API load balancer

Port	Back-end machines (pool members)	Internal	External	Description

Port	Back-end machines (pool members)	Internal	External	Description
6443	Bootstrap and control plane. You remove the bootstrap machine from the load balancer after the bootstrap machine initializes the cluster control plane. You must configure the **/readyz** endpoint for the API server health check probe.	X	X	Kubernetes API server
22623	Bootstrap and control plane. You remove the bootstrap machine from the load balancer after the bootstrap machine initializes the cluster control plane.	X		Machine config server

NOTE

The load balancer must be configured to take a maximum of 30 seconds from the time the API server turns off the **/readyz** endpoint to the removal of the API server instance from the pool. Within the time frame after **/readyz** returns an error or becomes healthy, the endpoint must have been removed or added. Probing every 5 or 10 seconds, with two successful requests to become healthy and three to become unhealthy, are well-tested values.

2. **Application Ingress load balancer**: Provides an ingress point for application traffic flowing in from outside the cluster. A working configuration for the Ingress router is required for an OpenShift Container Platform cluster.
Configure the following conditions:

   - Layer 4 load balancing only. This can be referred to as Raw TCP, SSL Passthrough, or SSL Bridge mode. If you use SSL Bridge mode, you must enable Server Name Indication (SNI) for the ingress routes.
   - A connection-based or session-based persistence is recommended, based on the options available and types of applications that will be hosted on the platform.

TIP

If the true IP address of the client can be seen by the application Ingress load balancer, enabling source IP-based session persistence can improve performance for applications that use end-to-end TLS encryption.

Configure the following ports on both the front and back of the load balancers:

Table 16.26. Application Ingress load balancer

Port	Back-end machines (pool members)	Internal	External	Description
443	The machines that run the Ingress Controller pods, compute, or worker, by default.	X	X	HTTPS traffic
80	The machines that run the Ingress Controller pods, compute, or worker, by default.	X	X	HTTP traffic

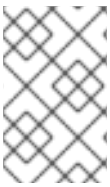
NOTE

If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application Ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes.

16.3.4.8.1. Example load balancer configuration for user-provisioned clusters

This section provides an example API and application ingress load balancer configuration that meets the load balancing requirements for user-provisioned clusters. The sample is an **/etc/haproxy/haproxy.cfg** configuration for an HAProxy load balancer. The example is not meant to provide advice for choosing one load balancing solution over another.

In the example, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.



NOTE

If you are using HAProxy as a load balancer and SELinux is set to **enforcing**, you must ensure that the HAProxy service can bind to the configured TCP port by running **setsebool -P haproxy_connect_any=1**.

Example 16.6. Sample API and application Ingress load balancer configuration

```
global
  log         127.0.0.1 local2
  pidfile     /var/run/haproxy.pid
  maxconn     4000
  daemon
defaults
  mode                    http
  log                     global
  option                  dontlognull
  option http-server-close
  option                  redispatch
  retries                 3
  timeout http-request    10s
  timeout queue           1m
  timeout connect         10s
```

```
    timeout client          1m
    timeout server          1m
    timeout http-keep-alive 10s
    timeout check           10s
    maxconn                 3000
listen api-server-6443 (1)
    bind *:6443
    mode tcp
    server bootstrap bootstrap.ocp4.example.com:6443 check inter 1s backup (2)
    server master0 master0.ocp4.example.com:6443 check inter 1s
    server master1 master1.ocp4.example.com:6443 check inter 1s
    server master2 master2.ocp4.example.com:6443 check inter 1s
listen machine-config-server-22623 (3)
    bind *:22623
    mode tcp
    option  httpchk GET /readyz HTTP/1.0
    option  log-health-checks
    balance roundrobin
    server bootstrap bootstrap.ocp4.example.com:6443 verify none check check-ssl inter 10s fall 2
rise 3 backup (4)
    server master0 master0.ocp4.example.com:6443 weight 1 verify none check check-ssl inter 10s
fall 2 rise 3
    server master1 master1.ocp4.example.com:6443 weight 1 verify none check check-ssl inter 10s
fall 2 rise 3
    server master2 master2.ocp4.example.com:6443 weight 1 verify none check check-ssl inter 10s
fall 2 rise 3
listen ingress-router-443 (5)
    bind *:443
    mode tcp
    balance source
    server worker0 worker0.ocp4.example.com:443 check inter 1s
    server worker1 worker1.ocp4.example.com:443 check inter 1s
listen ingress-router-80 (6)
    bind *:80
    mode tcp
    balance source
    server worker0 worker0.ocp4.example.com:80 check inter 1s
    server worker1 worker1.ocp4.example.com:80 check inter 1s
```

(1) Port **6443** handles the Kubernetes API traffic and points to the control plane machines.

(2) (4) The bootstrap entries must be in place before the OpenShift Container Platform cluster installation and they must be removed after the bootstrap process is complete.

(3) Port **22623** handles the machine config server traffic and points to the control plane machines.

(5) Port **443** handles the HTTPS traffic and points to the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.

(6) Port **80** handles the HTTP traffic and points to the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.

NOTE

If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application Ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes.

TIP

If you are using HAProxy as a load balancer, you can check that the **haproxy** process is listening on ports **6443**, **22623**, **443**, and **80** by running **netstat -nltupe** on the HAProxy node.

16.3.5. Preparing the user-provisioned infrastructure

Before you install OpenShift Container Platform on user-provisioned infrastructure, you must prepare the underlying infrastructure.

This section provides details about the high-level steps required to set up your cluster infrastructure in preparation for an OpenShift Container Platform installation. This includes configuring IP networking and network connectivity for your cluster nodes, preparing a web server for the Ignition files, enabling the required ports through your firewall, and setting up the required DNS and load balancing infrastructure.

After preparation, your cluster infrastructure must meet the requirements outlined in the *Requirements for a cluster with user-provisioned infrastructure* section.

Prerequisites

- You have reviewed the OpenShift Container Platform 4.x Tested Integrations page.
- You have reviewed the infrastructure requirements detailed in the *Requirements for a cluster with user-provisioned infrastructure* section.

Procedure

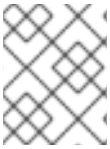
1. Set up static IP addresses.
2. Set up an HTTP or HTTPS server to provide Ignition files to the cluster nodes.
3. Ensure that your network infrastructure provides the required network connectivity between the cluster components. See the *Networking requirements for user-provisioned infrastructure* section for details about the requirements.
4. Configure your firewall to enable the ports required for the OpenShift Container Platform cluster components to communicate. See *Networking requirements for user-provisioned infrastructure* section for details about the ports that are required.

IMPORTANT

By default, port **1936** is accessible for an OpenShift Container Platform cluster, because each control plane node needs access to this port.

Avoid using the Ingress load balancer to expose this port, because doing so might result in the exposure of sensitive information, such as statistics and metrics, related to Ingress Controllers.

5. Setup the required DNS infrastructure for your cluster.
    a. Configure DNS name resolution for the Kubernetes API, the application wildcard, the bootstrap machine, the control plane machines, and the compute machines.
    b. Configure reverse DNS resolution for the Kubernetes API, the bootstrap machine, the control plane machines, and the compute machines.
    See the *User-provisioned DNS requirements* section for more information about the OpenShift Container Platform DNS requirements.
6. Validate your DNS configuration.
    a. From your installation node, run DNS lookups against the record names of the Kubernetes API, the wildcard routes, and the cluster nodes. Validate that the IP addresses in the responses correspond to the correct components.
    b. From your installation node, run reverse DNS lookups against the IP addresses of the load balancer and the cluster nodes. Validate that the record names in the responses correspond to the correct components.
    See the *Validating DNS resolution for user-provisioned infrastructure* section for detailed DNS validation steps.
7. Provision the required API and application ingress load balancing infrastructure. See the *Load balancing requirements for user-provisioned infrastructure* section for more information about the requirements.



NOTE

Some load balancing solutions require the DNS name resolution for the cluster nodes to be in place before the load balancing is initialized.

16.3.6. Validating DNS resolution for user-provisioned infrastructure

You can validate your DNS configuration before installing OpenShift Container Platform on user-provisioned infrastructure.

IMPORTANT

The validation steps detailed in this section must succeed before you install your cluster.

Prerequisites

- You have configured the required DNS records for your user-provisioned infrastructure.

Procedure

1. From your installation node, run DNS lookups against the record names of the Kubernetes API, the wildcard routes, and the cluster nodes. Validate that the IP addresses contained in the responses correspond to the correct components.

   a. Perform a lookup against the Kubernetes API record name. Check that the result points to the IP address of the API load balancer:

   ```
   $ dig +noall +answer @<nameserver_ip> api.<cluster_name>.<base_domain> 1
   ```

   1 Replace **<nameserver_ip>** with the IP address of the nameserver, **<cluster_name>** with your cluster name, and **<base_domain>** with your base domain name.

   Example output

   ```
   api.ocp4.example.com.  604800 IN A 192.168.1.5
   ```

   b. Perform a lookup against the Kubernetes internal API record name. Check that the result points to the IP address of the API load balancer:

   ```
   $ dig +noall +answer @<nameserver_ip> api-int.<cluster_name>.<base_domain>
   ```

   Example output

   ```
   api-int.ocp4.example.com.  604800 IN A 192.168.1.5
   ```

   c. Test an example ***.apps.<cluster_name>.<base_domain>** DNS wildcard lookup. All of the application wildcard lookups must resolve to the IP address of the application ingress load balancer:

   ```
   $ dig +noall +answer @<nameserver_ip> random.apps.<cluster_name>.<base_domain>
   ```

   Example output

   ```
   random.apps.ocp4.example.com.  604800 IN A 192.168.1.5
   ```

   NOTE

   In the example outputs, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

   You can replace **random** with another wildcard value. For example, you can query the route to the OpenShift Container Platform console:

   ```
   $ dig +noall +answer @<nameserver_ip> console-openshift-console.apps.
   <cluster_name>.<base_domain>
   ```

   Example output

   ```
   console-openshift-console.apps.ocp4.example.com. 604800 IN A 192.168.1.5
   ```

d. Run a lookup against the bootstrap DNS record name. Check that the result points to the IP address of the bootstrap node:

```
$ dig +noall +answer @<nameserver_ip> bootstrap.<cluster_name>.<base_domain>
```

Example output

```
bootstrap.ocp4.example.com.  604800 IN A 192.168.1.96
```

e. Use this method to perform lookups against the DNS record names for the control plane and compute nodes. Check that the results correspond to the IP addresses of each node.

2. From your installation node, run reverse DNS lookups against the IP addresses of the load balancer and the cluster nodes. Validate that the record names contained in the responses correspond to the correct components.

a. Perform a reverse lookup against the IP address of the API load balancer. Check that the response includes the record names for the Kubernetes API and the Kubernetes internal API:

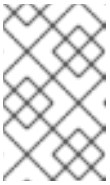
```
$ dig +noall +answer @<nameserver_ip> -x 192.168.1.5
```

Example output

```
5.1.168.192.in-addr.arpa. 604800 IN PTR api-int.ocp4.example.com. 1
5.1.168.192.in-addr.arpa. 604800 IN PTR api.ocp4.example.com. 2
```

1 Provides the record name for the Kubernetes internal API.

2 Provides the record name for the Kubernetes API.



NOTE

A PTR record is not required for the OpenShift Container Platform application wildcard. No validation step is needed for reverse DNS resolution against the IP address of the application ingress load balancer.

b. Perform a reverse lookup against the IP address of the bootstrap node. Check that the result points to the DNS record name of the bootstrap node:

```
$ dig +noall +answer @<nameserver_ip> -x 192.168.1.96
```

Example output

```
96.1.168.192.in-addr.arpa. 604800 IN PTR bootstrap.ocp4.example.com.
```

c. Use this method to perform reverse lookups against the IP addresses for the control plane and compute nodes. Check that the results correspond to the DNS record names of each node.

16.3.7. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the **~/.ssh/authorized_keys** list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The **./openshift-install gather** command also requires the SSH public key to be in place on the cluster nodes.

IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.

Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N '' -f <path>/<file_name> 1
```

1 Specify the path and file name, such as **~/.ssh/id_ed25519**, of the new SSH key. If you have an existing key pair, ensure your public key is in the your **~/.ssh** directory.

NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS validated or Modules In Process cryptographic libraries on the **x86_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

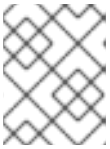
2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the **~/.ssh/id_ed25519.pub** public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the **./openshift-install gather** command.



NOTE

On some distributions, default SSH private key identities such as ~/**.ssh/id_rsa** and ~/**.ssh/id_dsa** are managed automatically.

a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

Example output

```
Agent pid 31874
```

NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

1 Specify the path and file name for your SSH private key, such as ~/**.ssh/id_ed25519**

Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

16.3.8. Manually creating the installation configuration file

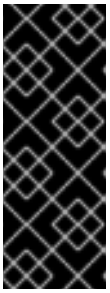
Prerequisites

- You have an SSH public key on your local machine to provide to the installation program. The key will be used for SSH authentication onto your cluster nodes for debugging and disaster recovery.
- You have obtained the OpenShift Container Platform installation program and the pull secret for your cluster.

Procedure

1. Create an installation directory to store your required installation assets in:

```
$ mkdir <installation_directory>
```



IMPORTANT

You must create a directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

2. Customize the sample **install-config.yaml** file template that is provided and save it in the **<installation_directory>**.

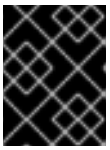
NOTE

You must name this configuration file **install-config.yaml**.

NOTE

For some platform types, you can alternatively run **./openshift-install create install-config --dir <installation_directory>** to generate an **install-config.yaml** file. You can provide details about your cluster configuration at the prompts.

3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.



IMPORTANT

The **install-config.yaml** file is consumed during the next step of the installation process. You must back it up now.

16.3.8.1. Installation configuration parameters

Before you deploy an OpenShift Container Platform cluster, you provide a customized **install-config.yaml** installation configuration file that describes the details for your environment.

NOTE

After installation, you cannot modify these parameters in the **install-config.yaml** file.

16.3.8.1.1. Required configuration parameters

Required installation configuration parameters are described in the following table:

Table 16.27. Required parameters

Parameter	Description	Values
apiVersion	The API version for the **install-config.yaml** content. The current version is **v1**. The installer may also support older API versions.	String

Parameter	Description	Values
baseDomain	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the **baseDomain** and **metadata.name** parameter values that uses the **<metadata.name>.<baseDomain>** format.	A fully-qualified domain or subdomain name, such as **example.com**.
metadata	Kubernetes resource **ObjectMeta**, from which only the **name** parameter is consumed.	Object
metadata.name	The name of the cluster. DNS records for the cluster are all subdomains of **{{.metadata.name}}.{{.baseDomain}}**.	String of lowercase letters, hyphens (**-**), and periods (**.**), such as **dev**.
platform	The configuration for the specific platform upon which to perform the installation: **alibabacloud**, **aws**, **baremetal**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**. For additional information about **platform.<platform>** parameters, consult the table for your specific platform that follows.	Object

Parameter	Description	Values
pullSecret	Get a pull secret from the Red Hat OpenShift Cluster Manager to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	<pre>{ "auths":{ "cloud.openshift.com":{ "auth":"b3Blb=", "email":"you@example.com" }, "quay.io":{ "auth":"b3Blb=", "email":"you@example.com" } } }</pre>

16.3.8.1.2. Network configuration parameters

You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

Only IPv4 addresses are supported.

NOTE

Globalnet is not supported with Red Hat OpenShift Data Foundation disaster recovery solutions. For regional disaster recovery scenarios, ensure that you use a nonoverlapping range of private IP addresses for the cluster and service networks in each cluster.

Table 16.28. Network parameters

Parameter	Description	Values
networking	The configuration for the cluster network.	Object  **NOTE** You cannot modify parameters specified by the **networking** object after installation.

Parameter	Description	Values
networking.networkType	The cluster network provider Container Network Interface (CNI) cluster network provider to install.	Either **OpenShiftSDN** or **OVNKubernetes**. **OpenShiftSDN** is a CNI provider for all-Linux networks. **OVNKubernetes** is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is **OpenShiftSDN**.
networking.clusterNetwork	The IP address blocks for pods. The default value is **10.128.0.0/14** with a host prefix of **/23**. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: `networking:` `  clusterNetwork:` `  - cidr: 10.128.0.0/14` `    hostPrefix: 23`
networking.clusterNetwork.cidr	Required if you use **networking.clusterNetwork**. An IP address block. An IPv4 network.	An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between **0** and **32**.
networking.clusterNetwork.hostPrefix	The subnet prefix length to assign to each individual node. For example, if **hostPrefix** is set to **23** then each node is assigned a **/23** subnet out of the given **cidr**. A **hostPrefix** value of **23** provides 510 (2^(32 - 23) - 2) pod IP addresses.	A subnet prefix. The default value is **23**.
networking.serviceNetwork	The IP address block for services. The default value is **172.30.0.0/16**. The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.	An array with an IP address block in CIDR format. For example: `networking:` `  serviceNetwork:` `   - 172.30.0.0/16`
networking.machineNetwork	The IP address blocks for machines. If you specify multiple IP address blocks, the blocks must not overlap. If you specify multiple IP kernel arguments, the **machineNetwork.cidr** value must be the CIDR of the primary network.	An array of objects. For example: `networking:` `  machineNetwork:` `  - cidr: 10.0.0.0/16`

Parameter	Description	Values
networking.machineNetwork.cidr	Required if you use **networking.machineNetwork**. An IP address block. The default value is **10.0.0.0/16** for all platforms other than libvirt. For libvirt, the default value is **192.168.126.0/24**.	An IP network block in CIDR notation. For example, **10.0.0.0/16**.  **NOTE** Set the **networking.machineNetwork** to match the CIDR that the preferred NIC resides in.

16.3.8.1.3. Optional configuration parameters

Optional installation configuration parameters are described in the following table:

Table 16.29. Optional parameters

Parameter	Description	Values
additionalTrustBundle	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String
capabilities	Controls the installation of optional core cluster components. You can reduce the footprint of your OpenShift Container Platform cluster by disabling optional components.	String array
capabilities.baselineCapabilitySet	Selects an initial set of optional capabilities to enable. Valid values are **None**, **v4.11** and **vCurrent**. **v4.11** enables the **baremetal** Operator, the **marketplace** Operator, and the **openshift-samples** content. **vCurrent** installs the recommended set of capabilities for the current version of OpenShift Container Platform. The default value is **vCurrent**.	String

Parameter	Description	Values
capabilities.additionalEnabledCapabilities	Extends the set of optional capabilities beyond what you specify in **baselineCapabilitySet**. Valid values are **baremetal**, **marketplace** and **openshift-samples**. You may specify multiple capabilities in this parameter.	String array
cgroupsV2	Enables Linux control groups version 2 (cgroups v2) on specific nodes in your cluster. The OpenShift Container Platform process for enabling cgroups v2 disables all cgroup version 1 controllers and hierarchies. The OpenShift Container Platform cgroups version 2 feature is in Developer Preview and is not supported by Red Hat at this time.	**true**
compute	The configuration for the machines that comprise the compute nodes.	Array of **MachinePool** objects.
compute.architecture	Determines the instruction set architecture of the machines in the pool. Currently, heteregeneous clusters are not supported, so all pools must specify the same architecture. Valid values are **s390x** (the default).	String
compute.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  **IMPORTANT** If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
compute.name	Required if you use **compute**. The name of the machine pool.	**worker**

Parameter	Description	Values
compute.platform	Required if you use **compute**. Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the **controlPlane.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
compute.replicas	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to **2**. The default value is **3**.
controlPlane	The configuration for the machines that comprise the control plane.	Array of **MachinePool** objects.
controlPlane.architecture	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are **s390x** (the default).	String
controlPlane.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  IMPORTANT If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
controlPlane.name	Required if you use **controlPlane**. The name of the machine pool.	**master**
controlPlane.platform	Required if you use **controlPlane**. Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the **compute.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**

Parameter	Description	Values
controlPlane.replicas	The number of control plane machines to provision.	The only supported value is **3**, which is the default value.
credentialsMode	The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported.  **NOTE** Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the *Cloud Credential Operator* entry in the *Cluster Operators reference* content.  **NOTE** If your AWS account has service control policies (SCP) enabled, you must configure the **credentialsMode** parameter to **Mint**, **Passthrough** or **Manual**.	**Mint**, **Passthrough**, **Manual** or an empty string (**""**).

Parameter	Description	Values
fips	Enable or disable FIPS mode. The default is **false** (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.  **IMPORTANT** To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.  **NOTE** If you are using Azure File storage, you cannot enable FIPS mode.	**false** or **true**
imageContentSources	Sources and repositories for the release-image content.	Array of objects. Includes a **source** and, optionally, **mirrors**, as described in the following rows of this table.
imageContentSources.source	Required if you use **imageContentSources**. Specify the repository that users refer to, for example, in image pull specifications.	String

Parameter	Description	Values
imageContentSources.mirrors	Specify one or more repositories that may also contain the same images.	Array of strings
publish	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	**Internal** or **External**. The default value is **External**. Setting this field to **Internal** is not supported on non-cloud platforms and IBM Cloud VPC.  IMPORTANT If the value of the field is set to **Internal**, the cluster will become non-functional. For more information, refer to BZ#1953035.
sshKey	The SSH key to authenticate access to your cluster machines.  NOTE For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.	For example, **sshKey: ssh-ed25519 AAAA..**.

16.3.8.2. Sample install-config.yaml file for IBM Z

You can customize the **install-config.yaml** file to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.

```
apiVersion: v1
baseDomain: example.com (1)
compute: (2)
- hyperthreading: Enabled (3)
  name: worker
  replicas: 0 (4)
  architecture : s390x
controlPlane: (5)
  hyperthreading: Enabled (6)
  name: master
```

```
  replicas: 3 7
  architecture : s390x
metadata:
  name: test 8
networking:
  clusterNetwork:
  - cidr: 10.128.0.0/14 9
    hostPrefix: 23 10
  networkType: OpenShiftSDN
  serviceNetwork: 11
  - 172.30.0.0/16
platform:
  none: {} 12
fips: false 13
pullSecret: '{"auths":{"<local_registry>": {"auth": "<credentials>","email": "you@example.com"}}}' 14
sshKey: 'ssh-ed25519 AAAA...' 15
additionalTrustBundle: | 16
  -----BEGIN CERTIFICATE-----
  ZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZ
  -----END CERTIFICATE-----
imageContentSources: 17
- mirrors:
  - <local_repository>/ocp4/openshift4
  source: quay.io/openshift-release-dev/ocp-release
- mirrors:
  - <local_repository>/ocp4/openshift4
  source: quay.io/openshift-release-dev/ocp-v4.0-art-dev
```

1 The base domain of the cluster. All DNS records must be sub-domains of this base and include the cluster name.

2 5 The **controlPlane** section is a single mapping, but the **compute** section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, **-**, and the first line of the **controlPlane** section must not. Only one control plane pool is used.

3 6 Specifies whether to enable or disable simultaneous multithreading (SMT), or hyperthreading. By default, SMT is enabled to increase the performance of the cores in your machines. You can disable it by setting the parameter value to **Disabled**. If you disable SMT, you must disable it in all cluster machines; this includes both control plane and compute machines.

NOTE

Simultaneous multithreading (SMT) is enabled by default. If SMT is not available on your OpenShift Container Platform nodes, the **hyperthreading** parameter has no effect.

IMPORTANT

If you disable **hyperthreading**, whether on your OpenShift Container Platform nodes or in the **install-config.yaml** file, ensure that your capacity planning accounts for the dramatically decreased machine performance.

4 You must set this value to **0** when you install OpenShift Container Platform on user-provisioned infrastructure. In installer-provisioned installations, the parameter controls the number of compute

NOTE

If you are installing a three-node cluster, do not deploy any compute machines when you install the Red Hat Enterprise Linux CoreOS (RHCOS) machines.

7 The number of control plane machines that you add to the cluster. Because the cluster uses these values as the number of etcd endpoints in the cluster, the value must match the number of control plane machines that you deploy.

8 The cluster name that you specified in your DNS records.

9 A block of IP addresses from which pod IP addresses are allocated. This block must not overlap with existing physical networks. These IP addresses are used for the pod network. If you need to access the pods from an external network, you must configure load balancers and routers to manage the traffic.

NOTE

Class E CIDR range is reserved for a future use. To use the Class E CIDR range, you must ensure your networking environment accepts the IP addresses within the Class E CIDR range.

10 The subnet prefix length to assign to each individual node. For example, if **hostPrefix** is set to **23**, then each node is assigned a **/23** subnet out of the given **cidr**, which allows for 510 (2^(32 - 23) - 2) pod IP addresses. If you are required to provide access to nodes from an external network, configure load balancers and routers to manage the traffic.

11 The IP address pool to use for service IP addresses. You can enter only one IP address pool. This block must not overlap with existing physical networks. If you need to access the services from an external network, configure load balancers and routers to manage the traffic.

12 You must set the platform to **none**. You cannot provide additional platform configuration variables for IBM Z infrastructure.

IMPORTANT

Clusters that are installed with the platform type **none** are unable to use some features, such as managing compute machines with the Machine API. This limitation applies even if the compute machines that are attached to the cluster are installed on a platform that would normally support the feature. This parameter cannot be changed after installation.

13 Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.

IMPORTANT

To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.

14 For **<local_registry>**, specify the registry domain name, and optionally the port, that your mirror registry uses to serve content. For example, **registry.example.com** or **registry.example.com:5000**. For **<credentials>**, specify the base64-encoded user name and password for your mirror registry.

15 The SSH public key for the **core** user in Red Hat Enterprise Linux CoreOS (RHCOS).

NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

16 Add the **additionalTrustBundle** parameter and value. The value must be the contents of the certificate file that you used for your mirror registry. The certificate file can be an existing, trusted certificate authority or the self-signed certificate that you generated for the mirror registry.

17 Provide the **imageContentSources** section from the output of the command to mirror the repository.

16.3.8.3. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.

NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
```

1. A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
2. A proxy URL to use for creating HTTPS connections outside the cluster.
3. A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use ***** to bypass the proxy for all destinations.
4. If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace that contains one or more additional CA certificates that are required for proxying HTTPS connections. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges these contents with the Red Hat Enterprise Linux CoreOS (RHCOS) trust bundle, and this config map is referenced in the **trustedCA** field of the **Proxy** object. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.

NOTE

The installation program does not support the proxy **readinessEndpoints** field.

NOTE

If the installer times out, restart and then complete the deployment by using the **wait-for** command of the installer. For example:

```
$ ./openshift-install wait-for install-complete --log-level debug
```

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.

NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

16.3.8.4. Configuring a three-node cluster

Optionally, you can deploy zero compute machines in a minimal three node cluster that consists of three control plane machines only. This provides smaller, more resource efficient clusters for cluster administrators and developers to use for testing, development, and production.

In three-node OpenShift Container Platform environments, the three control plane machines are schedulable, which means that your application workloads are scheduled to run on them.

Prerequisites

- You have an existing **install-config.yaml** file.

Procedure

- Ensure that the number of compute replicas is set to **0** in your **install-config.yaml** file, as shown in the following **compute** stanza:

```
compute:
- name: worker
  platform: {}
  replicas: 0
```

NOTE

You must set the value of the **replicas** parameter for the compute machines to **0** when you install OpenShift Container Platform on user-provisioned infrastructure, regardless of the number of compute machines you are deploying. In installer-provisioned installations, the parameter controls the number of compute machines that the cluster creates and manages for you. This does not apply to user-provisioned installations, where the compute machines are deployed manually.

NOTE

The preferred resource for control plane nodes is six vCPUs and 21 GB. For three control plane nodes this is the memory + vCPU equivalent of a minimum five-node cluster. You should back the three nodes, each installed on a 120 GB disk, with three IFLs that are SMT2 enabled. The minimum tested setup is three vCPUs and 10 GB on a 120 GB disk for each control plane node.

For three-node cluster installations, follow these next steps:

- If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes. See the *Load balancing requirements for user-provisioned infrastructure* section for more information.

- When you create the Kubernetes manifest files in the following procedure, ensure that the **mastersSchedulable** parameter in the **<installation_directory>/manifests/cluster-scheduler-02-config.yml** file is set to **true**. This enables your application workloads to run on the control plane nodes.
- Do not deploy any compute nodes when you create the Red Hat Enterprise Linux CoreOS (RHCOS) machines.

16.3.9. Cluster Network Operator configuration

The configuration for the cluster network is specified as part of the Cluster Network Operator (CNO) configuration and stored in a custom resource (CR) object that is named **cluster**. The CR specifies the fields for the **Network** API in the **operator.openshift.io** API group.

The CNO configuration inherits the following fields during cluster installation from the **Network** API in the **Network.config.openshift.io** API group and these fields cannot be changed:

clusterNetwork

IP address pools from which pod IP addresses are allocated.

serviceNetwork

IP address pool for services.

defaultNetwork.type

Cluster network provider, such as OpenShift SDN or OVN-Kubernetes.

You can specify the cluster network provider configuration for your cluster by setting the fields for the **defaultNetwork** object in the CNO object named **cluster**.

16.3.9.1. Cluster Network Operator configuration object

The fields for the Cluster Network Operator (CNO) are described in the following table:

Table 16.30. Cluster Network Operator configuration object

Field	Type	Description
metadata.name	**string**	The name of the CNO object. This name is always **cluster**.
spec.clusterNetwork	**array**	A list specifying the blocks of IP addresses from which pod IP addresses are allocated and the subnet prefix length assigned to each individual node in the cluster. For example: `spec:` `  clusterNetwork:` `  - cidr: 10.128.0.0/19` `  hostPrefix: 23` `  - cidr: 10.128.32.0/19` `  hostPrefix: 23` You can customize this field only in the **install-config.yaml** file before you create the manifests. The value is read-only in the manifest file.

Field	Type	Description
spec.serviceNetwork	**array**	A block of IP addresses for services. The OpenShift SDN and OVN-Kubernetes Container Network Interface (CNI) network providers support only a single IP address block for the service network. For example: `spec:` `  serviceNetwork:` `  - 172.30.0.0/14` You can customize this field only in the **install-config.yaml** file before you create the manifests. The value is read-only in the manifest file.
spec.defaultNetwork	**object**	Configures the Container Network Interface (CNI) cluster network provider for the cluster network.
spec.kubeProxyConfig	**object**	The fields for this object specify the kube-proxy configuration. If you are using the OVN-Kubernetes cluster network provider, the kube-proxy configuration has no effect.

defaultNetwork object configuration

The values for the **defaultNetwork** object are defined in the following table:

Table 16.31. defaultNetwork object

Field	Type	Description
type	**string**	Either **OpenShiftSDN** or **OVNKubernetes**. The cluster network provider is selected during installation. This value cannot be changed after cluster installation.  **NOTE** OpenShift Container Platform uses the OpenShift SDN Container Network Interface (CNI) cluster network provider by default.
openshiftSDNConfig	**object**	This object is only valid for the OpenShift SDN cluster network provider.
ovnKubernetesConfig	**object**	This object is only valid for the OVN-Kubernetes cluster network provider.

Configuration for the OpenShift SDN CNI cluster network provider

The following table describes the configuration fields for the OpenShift SDN Container Network Interface (CNI) cluster network provider.

Table 16.32. **openshiftSDNConfig** object

Field	Type	Description
mode	**string**	Configures the network isolation mode for OpenShift SDN. The default value is **NetworkPolicy**. The values **Multitenant** and **Subnet** are available for backwards compatibility with OpenShift Container Platform 3.x but are not recommended. This value cannot be changed after cluster installation.
mtu	**integer**	The maximum transmission unit (MTU) for the VXLAN overlay network. This is detected automatically based on the MTU of the primary network interface. You do not normally need to override the detected MTU. If the auto-detected value is not what you expect it to be, confirm that the MTU on the primary network interface on your nodes is correct. You cannot use this option to change the MTU value of the primary network interface on the nodes. If your cluster requires different MTU values for different nodes, you must set this value to **50** less than the lowest MTU value in your cluster. For example, if some nodes in your cluster have an MTU of **9001**, and some have an MTU of**1500**, you must set this value to **1450**. This value cannot be changed after cluster installation.
vxlanPort	**integer**	The port to use for all VXLAN packets. The default value is **4789**. This value cannot be changed after cluster installation. If you are running in a virtualized environment with existing nodes that are part of another VXLAN network, then you might be required to change this. For example, when running an OpenShift SDN overlay on top of VMware NSX-T, you must select an alternate port for the VXLAN, because both SDNs use the same default VXLAN port number. On Amazon Web Services (AWS), you can select an alternate port for the VXLAN between port **9000** and port **9999**.

Example OpenShift SDN configuration

```
defaultNetwork:
  type: OpenShiftSDN
  openshiftSDNConfig:
    mode: NetworkPolicy
    mtu: 1450
    vxlanPort: 4789
```

Configuration for the OVN-Kubernetes CNI cluster network provider

The following table describes the configuration fields for the OVN-Kubernetes CNI cluster network provider.

Table 16.33. **ovnKubernetesConfig** object

Field	Type	Description
mtu	**integer**	The maximum transmission unit (MTU) for the Geneve (Generic Network Virtualization Encapsulation) overlay network. This is detected automatically based on the MTU of the primary network interface. You do not normally need to override the detected MTU. If the auto-detected value is not what you expect it to be, confirm that the MTU on the primary network interface on your nodes is correct. You cannot use this option to change the MTU value of the primary network interface on the nodes. If your cluster requires different MTU values for different nodes, you must set this value to **100** less than the lowest MTU value in your cluster. For example, if some nodes in your cluster have an MTU of **9001**, and some have an MTU of**1500**, you must set this value to **1400**.
genevePort	**integer**	The port to use for all Geneve packets. The default value is **6081**. This value cannot be changed after cluster installation.
ipsecConfig	**object**	Specify an empty object to enable IPsec encryption.
policyAuditConfig	**object**	Specify a configuration object for customizing network policy audit logging. If unset, the defaults audit log settings are used.
gatewayConfig	**object**	Optional: Specify a configuration object for customizing how egress traffic is sent to the node gateway.  **NOTE** While migrating egress traffic, you can expect some disruption to workloads and service traffic until the Cluster Network Operator (CNO) successfully rolls out the changes.

Table 16.34. **policyAuditConfig** object

Field	Type	Description
rateLimit	integer	The maximum number of messages to generate every second per node. The default value is **20** messages per second.

Field	Type	Description
maxFileSize	integer	The maximum size for the audit log in bytes. The default value is **50000000** or 50 MB.
destination	string	One of the following additional audit log targets: **libc** The libc **syslog()** function of the journald process on the host. **udp:<host>:<port>** A syslog server. Replace **<host>:<port>** with the host and port of the syslog server. **unix:<file>** A Unix Domain Socket file specified by **<file>**. **null** Do not send the audit logs to any additional target.
syslogFacility	string	The syslog facility, such as **kern**, as defined by RFC5424. The default value is **local0**.

Table 16.35. **gatewayConfig** object

Field	Type	Description
routingViaHost	**boolean**	Set this field to **true** to send egress traffic from pods to the host networking stack. For highly-specialized installations and applications that rely on manually configured routes in the kernel routing table, you might want to route egress traffic to the host networking stack. By default, egress traffic is processed in OVN to exit the cluster and is not affected by specialized routes in the kernel routing table. The default value is **false**. This field has an interaction with the Open vSwitch hardware offloading feature. If you set this field to **true**, you do not receive the performance benefits of the offloading because egress traffic is processed by the host networking stack.

Example OVN-Kubernetes configuration with IPSec enabled

```
defaultNetwork:
  type: OVNKubernetes
  ovnKubernetesConfig:
    mtu: 1400
    genevePort: 6081
    ipsecConfig: {}
```

kubeProxyConfig object configuration
The values for the **kubeProxyConfig** object are defined in the following table:

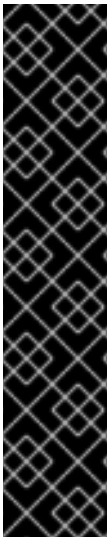
Table 16.36. **kubeProxyConfig** object

Field	Type	Description
iptablesSyncPeriod	**string**	The refresh period for **iptables** rules. The default value is **30s**. Valid suffixes include **s**, **m**, and **h** and are described in the Go **time** package documentation.  **NOTE** Because of performance improvements introduced in OpenShift Container Platform 4.3 and greater, adjusting the **iptablesSyncPeriod** parameter is no longer necessary.
proxyArguments.iptables-min-sync-period	**array**	The minimum duration before refreshing **iptables** rules. This field ensures that the refresh does not happen too frequently. Valid suffixes include **s**, **m**, and **h** and are described in the Go **time** package. The default value is: ``` kubeProxyConfig: proxyArguments: iptables-min-sync-period: - 0s ```

16.3.10. Creating the Kubernetes manifest and Ignition config files

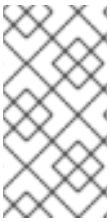
Because you must modify some cluster definition files and manually start the cluster machines, you must generate the Kubernetes manifest and Ignition config files that the cluster needs to configure the machines.

The installation configuration file transforms into the Kubernetes manifests. The manifests wrap into the Ignition configuration files, which are later used to configure the cluster machines.



IMPORTANT

- The Ignition config files that the OpenShift Container Platform installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.



NOTE

The installation program that generates the manifest and Ignition files is architecture specific and can be obtained from the client image mirror. The Linux version of the installation program runs on s390x only. This installer program is also available as a Mac OS version.

Prerequisites

- You obtained the OpenShift Container Platform installation program. For a restricted network installation, these files are on your mirror host.
- You created the **install-config.yaml** installation configuration file.

Procedure

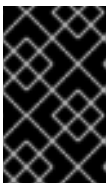
1. Change to the directory that contains the OpenShift Container Platform installation program and generate the Kubernetes manifests for the cluster:

```
$ ./openshift-install create manifests --dir <installation_directory> 1
```

1 For **<installation_directory>**, specify the installation directory that contains the **install-config.yaml** file you created.

WARNING

If you are installing a three-node cluster, skip the following step to allow the control plane nodes to be schedulable.



IMPORTANT

When you configure control plane nodes from the default unschedulable to schedulable, additional subscriptions are required. This is because control plane nodes then become compute nodes.

2. Check that the **mastersSchedulable** parameter in the **<installation_directory>/manifests/cluster-scheduler-02-config.yml** Kubernetes manifest file is set to **false**. This setting prevents pods from being scheduled on the control plane machines:
   a. Open the **<installation_directory>/manifests/cluster-scheduler-02-config.yml** file.
   b. Locate the **mastersSchedulable** parameter and ensure that it is set to **false**.
   c. Save and exit the file.
3. To create the Ignition configuration files, run the following command from the directory that contains the installation program:

```
$ ./openshift-install create ignition-configs --dir <installation_directory> 1
```

1 For **<installation_directory>**, specify the same installation directory.

Ignition config files are created for the bootstrap, control plane, and compute nodes in the installation directory. The **kubeadmin-password** and **kubeconfig** files are created in the **./<installation_directory>/auth** directory:

```
.
├── auth
│   ├── kubeadmin-password
│   └── kubeconfig
├── bootstrap.ign
├── master.ign
├── metadata.json
└── worker.ign
```

16.3.11. Installing RHCOS and starting the OpenShift Container Platform bootstrap process

To install OpenShift Container Platform on IBM Z infrastructure that you provision, you must install Red Hat Enterprise Linux CoreOS (RHCOS) on z/VM guest virtual machines. When you install RHCOS, you must provide the Ignition config file that was generated by the OpenShift Container Platform installation program for the type of machine you are installing. If you have configured suitable networking, DNS, and load balancing infrastructure, the OpenShift Container Platform bootstrap process begins automatically after the RHCOS z/VM guest virtual machines have rebooted.

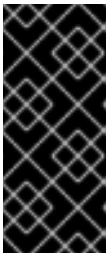
Complete the following steps to create the machines.

Prerequisites

- An HTTP or HTTPS server running on your provisioning machine that is accessible to the machines you create.

Procedure

1. Log in to Linux on your provisioning machine.
2. Obtain the Red Hat Enterprise Linux CoreOS (RHCOS) kernel, initramfs, and rootfs files from the RHCOS image mirror.



IMPORTANT

The RHCOS images might not change with every release of OpenShift Container Platform. You must download images with the highest version that is less than or equal to the OpenShift Container Platform version that you install. Only use the appropriate kernel, initramfs, and rootfs artifacts described in the following procedure.

The file names contain the OpenShift Container Platform version number. They resemble the following examples:

- kernel: **rhcos-<version>-live-kernel-<architecture>**

- initramfs: **rhcos-<version>-live-initramfs.<architecture>.img**
- rootfs: **rhcos-<version>-live-rootfs.<architecture>.img**

NOTE

The rootfs image is the same for FCP and DASD.

3. Create parameter files. The following parameters are specific for a particular virtual machine:
   - For **ip=**, specify the following seven entries:
     i. The IP address for the machine.
     ii. An empty string.
     iii. The gateway.
     iv. The netmask.
     v. The machine host and domain name in the form **hostname.domainname**. Omit this value to let RHCOS decide.
     vi. The network interface name. Omit this value to let RHCOS decide.
     vii. If you use static IP addresses, specify **none**.
   - For **coreos.inst.ignition_url=**, specify the Ignition file for the machine role. Use **bootstrap.ign**, **master.ign**, or **worker.ign**. Only HTTP and HTTPS protocols are supported.
   - For **coreos.live.rootfs_url=**, specify the matching rootfs artifact for the kernel and initramfs you are booting. Only HTTP and HTTPS protocols are supported.
   - For installations on DASD-type disks, complete the following tasks:
     i. For **coreos.inst.install_dev=**, specify **dasda**.
     ii. Use **rd.dasd=** to specify the DASD where RHCOS is to be installed.
     iii. Leave all other parameters unchanged.
     Example parameter file, **bootstrap-0.parm**, for the bootstrap machine:

```
rd.neednet=1 \
console=ttysclp0 \
coreos.inst.install_dev=dasda \
coreos.live.rootfs_url=http://cl1.provide.example.com:8080/assets/rhcos-live-rootfs.s390x.img \
coreos.inst.ignition_url=http://cl1.provide.example.com:8080/ignition/bootstrap.ign \
ip=172.18.78.2::172.18.78.1:255.255.255.0:::none nameserver=172.18.78.1 \
rd.znet=qeth,0.0.bdf0,0.0.bdf1,0.0.bdf2,layer2=1,portno=0 \
zfcp.allow_lun_scan=0 \
rd.dasd=0.0.3490
```

     Write all options in the parameter file as a single line and make sure you have no newline characters.

- For installations on FCP-type disks, complete the following tasks:

  i. Use **rd.zfcp=<adapter>,<wwpn>,<lun>** to specify the FCP disk where RHCOS is to be installed. For multipathing repeat this step for each additional path.

  NOTE

  When you install with multiple paths, you must enable multipathing directly after the installation, not at a later point in time, as this can cause problems.

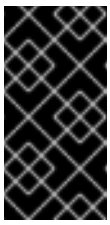
  ii. Set the install device as: **coreos.inst.install_dev=sda**.

  NOTE

  If additional LUNs are configured with NPIV, FCP requires **zfcp.allow_lun_scan=0**. If you must enable **zfcp.allow_lun_scan=1** because you use a CSI driver, for example, you must configure your NPIV so that each node cannot access the boot partition of another node.

  iii. Leave all other parameters unchanged.

  IMPORTANT

  Additional postinstallation steps are required to fully enable multipathing. For more information, see “Enabling multipathing with kernel arguments on RHCOS" in *Post-installation machine configuration tasks*.

  The following is an example parameter file **worker-1.parm** for a worker node with multipathing:

  ```
  rd.neednet=1 \
  console=ttysclp0 \
  coreos.inst.install_dev=sda \
  coreos.live.rootfs_url=http://cl1.provide.example.com:8080/assets/rhcos-live-rootfs.s390x.img \
  coreos.inst.ignition_url=http://cl1.provide.example.com:8080/ignition/worker.ign \
  ip=172.18.78.2::172.18.78.1:255.255.255.0:::none nameserver=172.18.78.1 \
  rd.znet=qeth,0.0.bdf0,0.0.bdf1,0.0.bdf2,layer2=1,portno=0 \
  zfcp.allow_lun_scan=0 \
  rd.zfcp=0.0.1987,0x50050763070bc5e3,0x4008400B00000000 \
  rd.zfcp=0.0.19C7,0x50050763070bc5e3,0x4008400B00000000 \
  rd.zfcp=0.0.1987,0x50050763071bc5e3,0x4008400B00000000 \
  rd.zfcp=0.0.19C7,0x50050763071bc5e3,0x4008400B00000000
  ```

  Write all options in the parameter file as a single line and make sure you have no newline characters.

4. Transfer the initramfs, kernel, parameter files, and RHCOS images to z/VM, for example with FTP. For details about how to transfer the files with FTP and boot from the virtual reader, see Installing under Z/VM.

5. Punch the files to the virtual reader of the z/VM guest virtual machine that is to become your bootstrap node.
   See PUNCH in IBM Documentation.

   TIP

   You can use the CP PUNCH command or, if you use Linux, the **vmur** command to transfer files between two z/VM guest virtual machines.

6. Log in to CMS on the bootstrap machine.
7. IPL the bootstrap machine from the reader:

   ```
   $ ipl c
   ```

   See IPL in IBM Documentation.

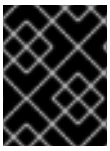
8. Repeat this procedure for the other machines in the cluster.

16.3.11.1. Advanced RHCOS installation reference

This section illustrates the networking configuration and other advanced options that allow you to modify the Red Hat Enterprise Linux CoreOS (RHCOS) manual installation process. The following tables describe the kernel arguments and command-line options you can use with the RHCOS live installer and the **coreos-installer** command.

16.3.11.1.1. Networking and bonding options for ISO installations

If you install RHCOS from an ISO image, you can add kernel arguments manually when you boot the image to configure networking for a node. If no networking arguments are specified, DHCP is activated in the initramfs when RHCOS detects that networking is required to fetch the Ignition config file.



IMPORTANT

When adding networking arguments manually, you must also add the **rd.neednet=1** kernel argument to bring the network up in the initramfs.

The following information provides examples for configuring networking and bonding on your RHCOS nodes for ISO installations. The examples describe how to use the **ip=**, **nameserver=**, and **bond=** kernel arguments.

NOTE

Ordering is important when adding the kernel arguments: **ip=**, **nameserver=**, and then **bond=**.

The networking options are passed to the **dracut** tool during system boot. For more information about the networking options supported by **dracut**, see the **dracut.cmdline** manual page.

The following examples are the networking options for ISO installation.

Configuring DHCP or static IP addresses

To configure an IP address, either use DHCP (**ip=dhcp**) or set an individual static IP address (**ip=<host_ip>**). If setting a static IP, you must then identify the DNS server IP address (**nameserver=<dns_ip>**) on each node. The following example sets:

- The node's IP address to **10.10.10.2**
- The gateway address to **10.10.10.254**
- The netmask to **255.255.255.0**
- The hostname to **core0.example.com**
- The DNS server address to **4.4.4.41**
- The auto-configuration value to **none**. No auto-configuration is required when IP networking is configured statically.

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp1s0:none
nameserver=4.4.4.41
```

NOTE

When you use DHCP to configure IP addressing for the RHCOS machines, the machines also obtain the DNS server information through DHCP. For DHCP-based deployments, you can define the DNS server address that is used by the RHCOS nodes through your DHCP server configuration.

Configuring an IP address without a static hostname
You can configure an IP address without assigning a static hostname. If a static hostname is not set by the user, it will be picked up and automatically set by a reverse DNS lookup. To configure an IP address without a static hostname refer to the following example:

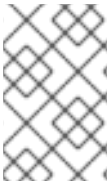
- The node's IP address to **10.10.10.2**
- The gateway address to **10.10.10.254**
- The netmask to **255.255.255.0**
- The DNS server address to **4.4.4.41**
- The auto-configuration value to **none**. No auto-configuration is required when IP networking is configured statically.

```
ip=10.10.10.2::10.10.10.254:255.255.255.0::enp1s0:none
nameserver=4.4.4.41
```

Specifying multiple network interfaces
You can specify multiple network interfaces by setting multiple **ip=** entries.

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp1s0:none
ip=10.10.10.3::10.10.10.254:255.255.255.0:core0.example.com:enp2s0:none
```

Configuring default gateway and route
Optional: You can configure routes to additional networks by setting an **rd.route=** value.



NOTE

When you configure one or multiple networks, one default gateway is required. If the additional network gateway is different from the primary network gateway, the default gateway must be the primary network gateway.

- Run the following command to configure the default gateway:

```
ip=::10.10.10.254::::
```

- Enter the following command to configure the route for the additional network:

```
rd.route=20.20.20.0/24:20.20.20.254:enp2s0
```

Disabling DHCP on a single interface
You can disable DHCP on a single interface, such as when there are two or more network interfaces and only one interface is being used. In the example, the **enp1s0** interface has a static networking configuration and DHCP is disabled for **enp2s0**, which is not used:

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp1s0:none
ip=::::core0.example.com:enp2s0:none
```

Combining DHCP and static IP configurations
You can combine DHCP and static IP configurations on systems with multiple network interfaces, for example:

```
ip=enp1s0:dhcp
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp2s0:none
```

Configuring VLANs on individual interfaces
Optional: You can configure VLANs on individual interfaces by using the **vlan=** parameter.

- To configure a VLAN on a network interface and use a static IP address, run the following command:

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp2s0.100:none
vlan=enp2s0.100:enp2s0
```

- To configure a VLAN on a network interface and to use DHCP, run the following command:

```
ip=enp2s0.100:dhcp
vlan=enp2s0.100:enp2s0
```

Providing multiple DNS servers
You can provide multiple DNS servers by adding a **nameserver=** entry for each server, for example:

```
nameserver=1.1.1.1
nameserver=8.8.8.8
```

Bonding multiple network interfaces to a single interface
Optional: You can bond multiple network interfaces to a single interface by using the **bond=** option. Refer to the following examples:

- The syntax for configuring a bonded interface is: **bond=name[:network_interfaces][:options]**
  name is the bonding device name (**bond0**), *network_interfaces* represents a comma-separated list of physical (ethernet) interfaces (**em1,em2**), and *options* is a comma-separated list of bonding options. Enter **modinfo bonding** to see available options.

- When you create a bonded interface using **bond=**, you must specify how the IP address is assigned and other information for the bonded interface.

- To configure the bonded interface to use DHCP, set the bond's IP address to **dhcp**. For example:

  ```
  bond=bond0:em1,em2:mode=active-backup
  ip=bond0:dhcp
  ```

- To configure the bonded interface to use a static IP address, enter the specific IP address you want and related information. For example:

```
bond=bond0:em1,em2:mode=active-backup,fail_over_mac=1
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:bond0:none
```

Always set option **fail_over_mac=1** in active-backup mode, to avoid problems when shared OSA/RoCE cards are used.

Bonding multiple network interfaces to a single interface
Optional: You can configure VLANs on bonded interfaces by using the **vlan=** parameter and to use DHCP, for example:

```
ip=bond0.100:dhcp
bond=bond0:em1,em2:mode=active-backup
vlan=bond0.100:bond0
```

Use the following example to configure the bonded interface with a VLAN and to use a static IP address:

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:bond0.100:none
bond=bond0:em1,em2:mode=active-backup
vlan=bond0.100:bond0
```

Using network teaming
Optional: You can use a network teaming as an alternative to bonding by using the **team=** parameter:

- The syntax for configuring a team interface is: **team=name[:network_interfaces]**
  name is the team device name (**team0**) and *network_interfaces* represents a comma-separated list of physical (ethernet) interfaces (**em1, em2**).

NOTE

Teaming is planned to be deprecated when RHCOS switches to an upcoming version of RHEL. For more information, see this Red Hat Knowledgebase Article .

Use the following example to configure a network team:

```
team=team0:em1,em2
ip=team0:dhcp
```

16.3.12. Waiting for the bootstrap process to complete

The OpenShift Container Platform bootstrap process begins after the cluster nodes first boot into the persistent RHCOS environment that has been installed to disk. The configuration information provided through the Ignition config files is used to initialize the bootstrap process and install OpenShift Container Platform on the machines. You must wait for the bootstrap process to complete.

Prerequisites

- You have created the Ignition config files for your cluster.
- You have configured suitable network, DNS and load balancing infrastructure.
- You have obtained the installation program and generated the Ignition config files for your cluster.
- You installed RHCOS on your cluster machines and provided the Ignition config files that the OpenShift Container Platform installation program generated.

Procedure

1. Monitor the bootstrap process:

```
$ ./openshift-install --dir <installation_directory> wait-for bootstrap-complete \ 1
    --log-level=info 2
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

Example output

```
INFO Waiting up to 30m0s for the Kubernetes API at https://api.test.example.com:6443...
INFO API v1.24.0 up
INFO Waiting up to 30m0s for bootstrapping to complete...
INFO It is now safe to remove the bootstrap resources
```

The command succeeds when the Kubernetes API server signals that it has been bootstrapped on the control plane machines.

2. After the bootstrap process is complete, remove the bootstrap machine from the load balancer.

IMPORTANT

You must remove the bootstrap machine from the load balancer at this point. You can also remove or reformat the bootstrap machine itself.

16.3.13. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container

Platform installation.

Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

Example output

```
system:admin
```

16.3.14. Approving the certificate signing requests for your machines

When you add machines to a cluster, two pending certificate signing requests (CSRs) are generated for each machine that you added. You must confirm that these CSRs are approved or, if necessary, approve them yourself. The client requests must be approved first, followed by the server requests.

Prerequisites

- You added machines to your cluster.

Procedure

1. Confirm that the cluster recognizes the machines:

```
$ oc get nodes
```

Example output

```
NAME     STATUS   ROLES   AGE  VERSION
master-0 Ready    master  63m  v1.24.0
master-1 Ready    master  63m  v1.24.0
master-2 Ready    master  64m  v1.24.0
```

The output lists all of the machines that you created.

NOTE

The preceding output might not include the compute nodes, also known as worker nodes, until some CSRs are approved.

2. Review the pending CSRs and ensure that you see the client requests with the **Pending** or **Approved** status for each machine that you added to the cluster:

```
$ oc get csr
```

Example output

```
NAME        AGE    REQUESTOR                                                   CONDITION
csr-8b2br   15m    system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper   Pending
csr-8vnps   15m    system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper   Pending
...
```

In this example, two machines are joining the cluster. You might see more approved CSRs in the list.

3. If the CSRs were not approved, after all of the pending CSRs for the machines you added are in **Pending** status, approve the CSRs for your cluster machines:

NOTE

Because the CSRs rotate automatically, approve your CSRs within an hour of adding the machines to the cluster. If you do not approve them within an hour, the certificates will rotate, and more than two certificates will be present for each node. You must approve all of these certificates. After the client CSR is approved, the Kubelet creates a secondary CSR for the serving certificate, which requires manual approval. Then, subsequent serving certificate renewal requests are automatically approved by the **machine-approver** if the Kubelet requests a new certificate with identical parameters.

NOTE

For clusters running on platforms that are not machine API enabled, such as bare metal and other user-provisioned infrastructure, you must implement a method of automatically approving the kubelet serving certificate requests (CSRs). If a request is not approved, then the **oc exec**, **oc rsh**, and **oc logs** commands cannot succeed, because a serving certificate is required when the API server connects to the kubelet. Any operation that contacts the Kubelet endpoint requires this certificate approval to be in place. The method must watch for new CSRs, confirm that the CSR was submitted by the **node-bootstrapper** service account in the **system:node** or **system:admin** groups, and confirm the identity of the node.

- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

1 **<csr_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{{"\n"}}
{{end}}{{end}}' | xargs --no-run-if-empty oc adm certificate approve
```

NOTE

Some Operators might not become available until some CSRs are approved.

4. Now that your client requests are approved, you must review the server requests for each machine that you added to the cluster:

```
$ oc get csr
```

Example output

```
NAME        AGE     REQUESTOR                                                   CONDITION
csr-bfd72   5m26s   system:node:ip-10-0-50-126.us-east-2.compute.internal
Pending
csr-c57lv   5m26s   system:node:ip-10-0-95-157.us-east-2.compute.internal
Pending
...
```

5. If the remaining CSRs are not approved, and are in the **Pending** status, approve the CSRs for your cluster machines:

- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

1 **<csr_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{{"\n"}}
{{end}}{{end}}' | xargs oc adm certificate approve
```

6. After all client and server CSRs have been approved, the machines have the **Ready** status. Verify this by running the following command:

```
$ oc get nodes
```

Example output

```
NAME      STATUS    ROLES   AGE  VERSION
master-0  Ready     master  73m  v1.24.0
master-1  Ready     master  73m  v1.24.0
```

```
master-2  Ready    master  74m  v1.24.0
worker-0  Ready    worker  11m  v1.24.0
worker-1  Ready    worker  11m  v1.24.0
```

NOTE

It can take a few minutes after approval of the server CSRs for the machines to transition to the **Ready** status.

Additional information

- For more information on CSRs, see Certificate Signing Requests.

16.3.15. Initial Operator configuration

After the control plane initializes, you must immediately configure some Operators so that they all become available.

Prerequisites

- Your control plane has initialized.

Procedure

1. Watch the cluster components come online:

```
$ watch -n5 oc get clusteroperators
```

Example output

```
NAME                                       VERSION   AVAILABLE   PROGRESSING   DEGRADED
SINCE
authentication                             4.11.0    True        False         False      19m
baremetal                                  4.11.0    True        False         False      37m
cloud-credential                           4.11.0    True        False         False      40m
cluster-autoscaler                         4.11.0    True        False         False      37m
config-operator                            4.11.0    True        False         False      38m
console                                    4.11.0    True        False         False      26m
csi-snapshot-controller                    4.11.0    True        False         False      37m
dns                                        4.11.0    True        False         False      37m
etcd                                       4.11.0    True        False         False      36m
image-registry                             4.11.0    True        False         False      31m
ingress                                    4.11.0    True        False         False      30m
insights                                   4.11.0    True        False         False      31m
kube-apiserver                             4.11.0    True        False         False      26m
kube-controller-manager                    4.11.0    True        False         False      36m
kube-scheduler                             4.11.0    True        False         False      36m
kube-storage-version-migrator              4.11.0    True        False         False      37m
machine-api                                4.11.0    True        False         False      29m
machine-approver                           4.11.0    True        False         False      37m
machine-config                             4.11.0    True        False         False      36m
marketplace                                4.11.0    True        False         False      37m
monitoring                                 4.11.0    True        False         False      29m
network                                    4.11.0    True        False         False      38m
```

```
node-tuning                                4.11.0    True        False         False      37m
openshift-apiserver                        4.11.0    True        False         False      32m
openshift-controller-manager               4.11.0    True        False         False      30m
openshift-samples                          4.11.0    True        False         False      32m
operator-lifecycle-manager                 4.11.0    True        False         False      37m
operator-lifecycle-manager-catalog         4.11.0    True        False         False      37m
operator-lifecycle-manager-packageserver   4.11.0    True        False         False      32m
service-ca                                 4.11.0    True        False         False      38m
storage                                    4.11.0    True        False         False      37m
```

2. Configure the Operators that are not available.

16.3.15.1. Disabling the default OperatorHub sources

Operator catalogs that source content provided by Red Hat and community projects are configured for OperatorHub by default during an OpenShift Container Platform installation. In a restricted network environment, you must disable the default catalogs as a cluster administrator.

Procedure

- Disable the sources for the default catalogs by adding **disableAllDefaultSources: true** to the **OperatorHub** object:

```
$ oc patch OperatorHub cluster --type json \
    -p '[{"op": "add", "path": "/spec/disableAllDefaultSources", "value": true}]'
```

TIP

Alternatively, you can use the web console to manage catalog sources. From the **Administration → Cluster Settings → Configuration → OperatorHub** page, click the **Sources** tab, where you can create, update, delete, disable, and enable individual sources.

16.3.15.2. Image registry storage configuration

The Image Registry Operator is not initially available for platforms that do not provide default storage. After installation, you must configure your registry to use storage so that the Registry Operator is made available.

Instructions are shown for configuring a persistent volume, which is required for production clusters. Where applicable, instructions are shown for configuring an empty directory as the storage location, which is available for only non-production clusters.

Additional instructions are provided for allowing the image registry to use block storage types by using the **Recreate** rollout strategy during upgrades.

16.3.15.2.1. Configuring registry storage for IBM Z

As a cluster administrator, following installation you must configure your registry to use storage.

Prerequisites

- You have access to the cluster as a user with the **cluster-admin** role.
- You have a cluster on IBM Z.

- You have provisioned persistent storage for your cluster, such as Red Hat OpenShift Data Foundation.

IMPORTANT

OpenShift Container Platform supports **ReadWriteOnce** access for image registry storage when you have only one replica. **ReadWriteOnce** access also requires that the registry uses the **Recreate** rollout strategy. To deploy an image registry that supports high availability with two or more replicas, **ReadWriteMany** access is required.

- Must have 100Gi capacity.

Procedure

1. To configure your registry to use storage, change the **spec.storage.pvc** in the **configs.imageregistry/cluster** resource.

NOTE

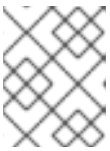
When you use shared storage, review your security settings to prevent outside access.

2. Verify that you do not have a registry pod:

```
$ oc get pod -n openshift-image-registry -l docker-registry=default
```

Example output

```
No resourses found in openshift-image-registry namespace
```



NOTE

If you do have a registry pod in your output, you do not need to continue with this procedure.

3. Check the registry configuration:

```
$ oc edit configs.imageregistry.operator.openshift.io
```

Example output

```
storage:
  pvc:
    claim:
```

Leave the **claim** field blank to allow the automatic creation of an **image-registry-storage** PVC.

4. Check the **clusteroperator** status:

```
$ oc get clusteroperator image-registry
```

Example output

```
NAME              VERSION       AVAILABLE   PROGRESSING   DEGRADED   SINCE
MESSAGE
image-registry    4.11          True        False         False      6h50m
```

5. Ensure that your registry is set to managed to enable building and pushing of images.

   - Run:

     ```
     $ oc edit configs.imageregistry/cluster
     ```

     Then, change the line

     ```
     managementState: Removed
     ```

     to

     ```
     managementState: Managed
     ```

16.3.15.2.2. Configuring storage for the image registry in non-production clusters

You must configure storage for the Image Registry Operator. For non-production clusters, you can set the image registry to an empty directory. If you do so, all images are lost if you restart the registry.

Procedure

- To set the image registry storage to an empty directory:

  ```
  $ oc patch configs.imageregistry.operator.openshift.io cluster --type merge --patch '{"spec":
  {"storage":{"emptyDir":{}}}}'
  ```

  WARNING

  Configure this option for only non-production clusters.

  If you run this command before the Image Registry Operator initializes its components, the **oc patch** command fails with the following error:

  ```
  Error from server (NotFound): configs.imageregistry.operator.openshift.io "cluster" not found
  ```

  Wait a few minutes and run the command again.

16.3.16. Completing installation on user-provisioned infrastructure

After you complete the Operator configuration, you can finish installing the cluster on infrastructure that you provide.

Prerequisites

- Your control plane has initialized.
- You have completed the initial Operator configuration.

Procedure

1. Confirm that all the cluster components are online with the following command:

```
$ watch -n5 oc get clusteroperators
```

Example output

```
NAME                                       VERSION   AVAILABLE   PROGRESSING   DEGRADED
SINCE
authentication                             4.11.0    True        False         False      19m
baremetal                                  4.11.0    True        False         False      37m
cloud-credential                           4.11.0    True        False         False      40m
cluster-autoscaler                         4.11.0    True        False         False      37m
config-operator                            4.11.0    True        False         False      38m
console                                    4.11.0    True        False         False      26m
csi-snapshot-controller                    4.11.0    True        False         False      37m
dns                                        4.11.0    True        False         False      37m
etcd                                       4.11.0    True        False         False      36m
image-registry                             4.11.0    True        False         False      31m
ingress                                    4.11.0    True        False         False      30m
insights                                   4.11.0    True        False         False      31m
kube-apiserver                             4.11.0    True        False         False      26m
kube-controller-manager                    4.11.0    True        False         False      36m
kube-scheduler                             4.11.0    True        False         False      36m
kube-storage-version-migrator              4.11.0    True        False         False      37m
machine-api                                4.11.0    True        False         False      29m
machine-approver                           4.11.0    True        False         False      37m
machine-config                             4.11.0    True        False         False      36m
marketplace                                4.11.0    True        False         False      37m
monitoring                                 4.11.0    True        False         False      29m
network                                    4.11.0    True        False         False      38m
node-tuning                                4.11.0    True        False         False      37m
openshift-apiserver                        4.11.0    True        False         False      32m
openshift-controller-manager               4.11.0    True        False         False      30m
openshift-samples                          4.11.0    True        False         False      32m
operator-lifecycle-manager                 4.11.0    True        False         False      37m
operator-lifecycle-manager-catalog         4.11.0    True        False         False      37m
operator-lifecycle-manager-packageserver   4.11.0    True        False         False      32m
service-ca                                 4.11.0    True        False         False      38m
storage                                    4.11.0    True        False         False      37m
```

Alternatively, the following command notifies you when all of the clusters are available. It also retrieves and displays credentials:

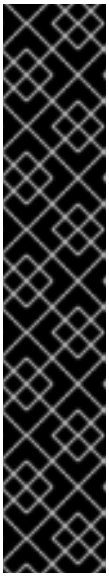
```
$ ./openshift-install --dir <installation_directory> wait-for install-complete 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

Example output

```
INFO Waiting up to 30m0s for the cluster to initialize...
```

The command succeeds when the Cluster Version Operator finishes deploying the OpenShift Container Platform cluster from Kubernetes API server.



IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

2. Confirm that the Kubernetes API server is communicating with the pods.

   a. To view a list of all pods, use the following command:

   ```
   $ oc get pods --all-namespaces
   ```

   Example output

   ```
   NAMESPACE                       NAME                                        READY   STATUS
   RESTARTS   AGE
   openshift-apiserver-operator    openshift-apiserver-operator-85cb746d55-zqhs8   1/1
   Running    1          9m
   openshift-apiserver             apiserver-67b9g                               1/1     Running     0
   3m
   openshift-apiserver             apiserver-ljcmx                               1/1     Running     0
   1m
   openshift-apiserver             apiserver-z25h4                               1/1     Running     0
   2m
   openshift-authentication-operator authentication-operator-69d5d8bf84-vh2n8        1/1
   Running    0          5m
   ...
   ```

   b. View the logs for a pod that is listed in the output of the previous command by using the following command:

   ```
   $ oc logs <pod_name> -n <namespace> 1
   ```

   1 Specify the pod name and namespace, as shown in the output of the previous command.

If the pod logs display, the Kubernetes API server can communicate with the cluster machines.

3. For an installation with Fibre Channel Protocol (FCP), additional steps are required to enable multipathing. Do not enable multipathing during installation.
   See "Enabling multipathing with kernel arguments on RHCOS" in the *Post-installation machine configuration tasks* documentation for more information.

4. Register your cluster on the Cluster registration page.

Additional resources

- How to generate SOSREPORT within OpenShift Container Platform version 4 nodes without SSH.

16.3.17. Next steps

- Customize your cluster.
- If the mirror registry that you used to install your cluster has a trusted CA, add it to the cluster by configuring additional trust stores.
- If necessary, you can opt out of remote health reporting .
- If necessary, see Registering your disconnected cluster

CHAPTER 17. INSTALLING WITH RHEL KVM ON IBM Z AND LINUXONE

17.1. PREPARING TO INSTALL WITH RHEL KVM ON IBM Z AND LINUXONE

17.1.1. Prerequisites

- You reviewed details about the OpenShift Container Platform installation and update processes.
- You read the documentation on selecting a cluster installation method and preparing it for users.

17.1.2. Choosing a method to install OpenShift Container Platform with RHEL KVM on IBM Z or LinuxONE

You can install a cluster with RHEL KVM on IBM Z or LinuxONE infrastructure that you provision, by using one of the following methods:

- **Installing a cluster with RHEL KVM on IBM Z and LinuxONE** You can install OpenShift Container Platform with KVM on IBM Z or LinuxONE infrastructure that you provision.
- **Installing a cluster with RHEL KVM on IBM Z and LinuxONE in a restricted network** You can install OpenShift Container Platform with RHEL KVM on IBM Z or LinuxONE infrastructure that you provision in a restricted or disconnected network, by using an internal mirror of the installation release content. You can use this method to install a cluster that does not require an active internet connection to obtain the software components. You can also use this installation method to ensure that your clusters only use container images that satisfy your organizational controls on external content.

17.2. INSTALLING A CLUSTER WITH RHEL KVM ON IBM Z AND LINUXONE

In OpenShift Container Platform version 4.11, you can install a cluster on IBM Z or LinuxONE infrastructure that you provision.

NOTE

While this document refers only to IBM Z, all information in it also applies to LinuxONE.

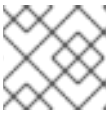
IMPORTANT

Additional considerations exist for non-bare metal platforms. Review the information in the guidelines for deploying OpenShift Container Platform on non-tested platforms before you install an OpenShift Container Platform cluster.

17.2.1. Prerequisites

- You reviewed details about the OpenShift Container Platform installation and update processes.

- You read the documentation on selecting a cluster installation method and preparing it for users.
- Before you begin the installation process, you must clean the installation directory. This ensures that the required installation files are created and updated during the installation process.
- You provisioned persistent storage using OpenShift Data Foundation or other supported storage protocols for your cluster. To deploy a private image registry, you must set up persistent storage with **ReadWriteMany** access.
- If you use a firewall, you configured it to allow the sites that your cluster requires access to.



NOTE

Be sure to also review this site list if you are configuring a proxy.

- You provisioned a RHEL Kernel Virtual Machine (KVM) system that is hosted on the logical partition (LPAR) and based on RHEL 8.4 or later. See Red Hat Enterprise Linux 8 and 9 Life Cycle.

17.2.2. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.11, you require access to the internet to install your cluster.

You must have internet access to:

- Access OpenShift Cluster Manager Hybrid Cloud Console to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access Quay.io to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.

IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

17.2.3. Machine requirements for a cluster with user-provisioned infrastructure

For a cluster that contains user-provisioned infrastructure, you must deploy all of the required machines.

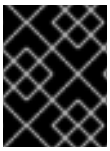
One or more KVM host machines based on RHEL 8.4 or later. Each RHEL KVM host machine must have libvirt installed and running. The virtual machines are provisioned under each RHEL KVM host machine.

17.2.3.1. Required machines

The smallest OpenShift Container Platform clusters require the following hosts:

Table 17.1. Minimum required hosts

Hosts	Description
One temporary bootstrap machine	The cluster requires the bootstrap machine to deploy the OpenShift Container Platform cluster on the three control plane machines. You can remove the bootstrap machine after you install the cluster.
Three control plane machines	The control plane machines run the Kubernetes and OpenShift Container Platform services that form the control plane.
At least two compute machines, which are also known as worker machines.	The workloads requested by OpenShift Container Platform users run on the compute machines.



IMPORTANT

To improve high availability of your cluster, distribute the control plane machines over different RHEL instances on at least two physical machines.

The bootstrap, control plane, and compute machines must use Red Hat Enterprise Linux CoreOS (RHCOS) as the operating system.

See Red Hat Enterprise Linux technology capabilities and limits .

17.2.3.2. Network connectivity requirements

The OpenShift Container Platform installer creates the Ignition files, which are necessary for all the Red Hat Enterprise Linux CoreOS (RHCOS) virtual machines. The automated installation of OpenShift Container Platform is performed by the bootstrap machine. It starts the installation of OpenShift Container Platform on each node, starts the Kubernetes cluster, and then finishes. During this bootstrap, the virtual machine must have an established network connection either through a Dynamic Host Configuration Protocol (DHCP) server or static IP address.

17.2.3.3. IBM Z network connectivity requirements

To install on IBM Z under RHEL KVM, you need:

- A RHEL KVM host configured with an OSA or RoCE network adapter.
- Either a RHEL KVM host that is configured to use bridged networking in libvirt or MacVTap to connect the network to the guests.
  See Types of virtual network connections .

17.2.3.4. Host machine resource requirements

The RHEL KVM host in your environment must meet the following requirements to host the virtual machines that you plan for the OpenShift Container Platform environment. See Getting started with virtualization.

You can install OpenShift Container Platform version 4.11 on the following IBM hardware:

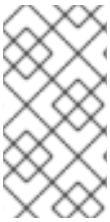
- IBM z16 (all models), IBM z15 (all models), IBM z14 (all models), IBM z13, and IBM z13s

- LinuxONE, any version

17.2.3.5. Minimum IBM Z system environment

Hardware requirements

- The equivalent of six Integrated Facilities for Linux (IFL), which are SMT2 enabled, for each cluster.
- At least one network connection to both connect to the **LoadBalancer** service and to serve data for traffic outside the cluster.



NOTE

You can use dedicated or shared IFLs to assign sufficient compute resources. Resource sharing is one of the key strengths of IBM Z. However, you must adjust capacity correctly on each hypervisor layer and ensure sufficient resources for every OpenShift Container Platform cluster.

IMPORTANT

Since the overall performance of the cluster can be impacted, the LPARs that are used to setup the OpenShift Container Platform clusters must provide sufficient compute capacity. In this context, LPAR weight management, entitlements, and CPU shares on the hypervisor level play an important role.

Operating system requirements

- One LPAR running on RHEL 8.4 or later with KVM, which is managed by libvirt

On your RHEL KVM host, set up:

- Three guest virtual machines for OpenShift Container Platform control plane machines
- Two guest virtual machines for OpenShift Container Platform compute machines
- One guest virtual machine for the temporary OpenShift Container Platform bootstrap machine

17.2.3.6. Minimum resource requirements

Each cluster virtual machine must meet the following minimum requirements:

Virtual Machine	Operating System	vCPU [1]	Virtual RAM	Storage	IOPS
Bootstrap	RHCOS	4	16 GB	100 GB	N/A
Control plane	RHCOS	4	16 GB	100 GB	N/A
Compute	RHCOS	2	8 GB	100 GB	N/A

1. One physical core (IFL) provides two logical cores (threads) when SMT-2 is enabled. The hypervisor can provide two or more vCPUs.

17.2.3.7. Preferred IBM Z system environment

Hardware requirements

- Three LPARS that each have the equivalent of six IFLs, which are SMT2 enabled, for each cluster.
- Two network connections to both connect to the **LoadBalancer** service and to serve data for traffic outside the cluster.

Operating system requirements

- For high availability, two or three LPARs running on RHEL 8.4 or later with KVM, which are managed by libvirt.

On your RHEL KVM host, set up:

- Three guest virtual machines for OpenShift Container Platform control plane machines, distributed across the RHEL KVM host machines.
- At least six guest virtual machines for OpenShift Container Platform compute machines, distributed across the RHEL KVM host machines.
- One guest virtual machine for the temporary OpenShift Container Platform bootstrap machine.
- To ensure the availability of integral components in an overcommitted environment, increase the priority of the control plane by using **cpu_shares**. Do the same for infrastructure nodes, if they exist. See schedinfo in IBM Documentation.

17.2.3.8. Preferred resource requirements

The preferred requirements for each cluster virtual machine are:

Virtual Machine	Operating System	vCPU	Virtual RAM	Storage
Bootstrap	RHCOS	4	16 GB	120 GB
Control plane	RHCOS	8	16 GB	120 GB
Compute	RHCOS	6	8 GB	120 GB

17.2.3.9. Certificate signing requests management

Because your cluster has limited access to automatic machine management when you use infrastructure that you provision, you must provide a mechanism for approving cluster certificate signing requests (CSRs) after installation. The **kube-controller-manager** only approves the kubelet client CSRs. The **machine-approver** cannot guarantee the validity of a serving certificate that is requested by using kubelet credentials because it cannot confirm that the correct machine issued the request. You must determine and implement a method of verifying the validity of the kubelet serving certificate requests and approving them.

Additional resources

- Recommended host practices for IBM Z & LinuxONE environments

17.2.3.10. Networking requirements for user-provisioned infrastructure

All the Red Hat Enterprise Linux CoreOS (RHCOS) machines require networking to be configured in **initramfs** during boot to fetch their Ignition config files.

During the initial boot, the machines require an IP address configuration that is set either through a DHCP server or statically by providing the required boot options. After a network connection is established, the machines download their Ignition config files from an HTTP or HTTPS server. The Ignition config files are then used to set the exact state of each machine. The Machine Config Operator completes more changes to the machines, such as the application of new certificates or keys, after installation.

It is recommended to use a DHCP server for long-term management of the cluster machines. Ensure that the DHCP server is configured to provide persistent IP addresses, DNS server information, and hostnames to the cluster machines.

NOTE

If a DHCP service is not available for your user-provisioned infrastructure, you can instead provide the IP networking configuration and the address of the DNS server to the nodes at RHCOS install time. These can be passed as boot arguments if you are installing from an ISO image. See the *Installing RHCOS and starting the OpenShift Container Platform bootstrap process* section for more information about static IP provisioning and advanced networking options.

The Kubernetes API server must be able to resolve the node names of the cluster machines. If the API servers and worker nodes are in different zones, you can configure a default DNS search zone to allow the API server to resolve the node names. Another supported approach is to always refer to hosts by their fully-qualified domain names in both the node objects and all DNS requests.

17.2.3.10.1. Setting the cluster node hostnames through DHCP

On Red Hat Enterprise Linux CoreOS (RHCOS) machines, the hostname is set through NetworkManager. By default, the machines obtain their hostname through DHCP. If the hostname is not provided by DHCP, set statically through kernel arguments, or another method, it is obtained through a reverse DNS lookup. Reverse DNS lookup occurs after the network has been initialized on a node and can take time to resolve. Other system services can start prior to this and detect the hostname as **localhost** or similar. You can avoid this by using DHCP to provide the hostname for each cluster node.

Additionally, setting the hostnames through DHCP can bypass any manual DNS record name configuration errors in environments that have a DNS split-horizon implementation.

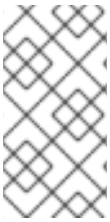
17.2.3.10.2. Network connectivity requirements

You must configure the network connectivity between machines to allow OpenShift Container Platform cluster components to communicate. Each machine must be able to resolve the hostnames of all other machines in the cluster.

This section provides details about the ports that are required.

IMPORTANT

In connected OpenShift Container Platform environments, all nodes are required to have internet access to pull images for platform containers and provide telemetry data to Red Hat.



NOTE

The RHEL KVM host must be configured to use bridged networking in libvirt or MacVTap to connect the network to the virtual machines. The virtual machines must have access to the network, which is attached to the RHEL KVM host. Virtual Networks, for example network address translation (NAT), within KVM are not a supported configuration.

Table 17.2. Ports used for all-machine to all-machine communications

Protocol	Port	Description
ICMP	N/A	Network reachability tests
TCP	**1936**	Metrics
	9000-**9999**	Host level services, including the node exporter on ports **9100**-**9101** and the Cluster Version Operator on port**9099**.
	10250-**10259**	The default ports that Kubernetes reserves
	10256	openshift-sdn
UDP	**4789**	VXLAN
	6081	Geneve
	9000-**9999**	Host level services, including the node exporter on ports **9100**-**9101**.
	500	IPsec IKE packets
	4500	IPsec NAT-T packets
TCP/UDP	**30000**-**32767**	Kubernetes node port
ESP	N/A	IPsec Encapsulating Security Payload (ESP)

Table 17.3. Ports used for all-machine to control plane communications

Protocol	Port	Description
TCP	**6443**	Kubernetes API

Table 17.4. Ports used for control plane machine to control plane machine communications

Protocol	Port	Description
TCP	**2379**-**2380**	etcd server and peer ports

NTP configuration for user-provisioned infrastructure
OpenShift Container Platform clusters are configured to use a public Network Time Protocol (NTP) server by default. If you want to use a local enterprise NTP server, or if your cluster is being deployed in a disconnected network, you can configure the cluster to use a specific time server. For more information, see the documentation for *Configuring chrony time service* .

If a DHCP server provides NTP server information, the chrony time service on the Red Hat Enterprise Linux CoreOS (RHCOS) machines read the information and can sync the clock with the NTP servers.

Additional resources

- Configuring chrony time service

17.2.3.11. User-provisioned DNS requirements

In OpenShift Container Platform deployments, DNS name resolution is required for the following components:

- The Kubernetes API
- The OpenShift Container Platform application wildcard
- The bootstrap, control plane, and compute machines

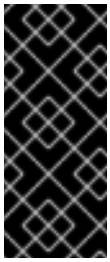
Reverse DNS resolution is also required for the Kubernetes API, the bootstrap machine, the control plane machines, and the compute machines.

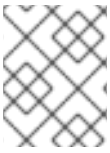
DNS A/AAAA or CNAME records are used for name resolution and PTR records are used for reverse name resolution. The reverse records are important because Red Hat Enterprise Linux CoreOS (RHCOS) uses the reverse records to set the hostnames for all the nodes, unless the hostnames are provided by DHCP. Additionally, the reverse records are used to generate the certificate signing requests (CSR) that OpenShift Container Platform needs to operate.

The following DNS records are required for a user-provisioned OpenShift Container Platform cluster and they must be in place before installation. In each record, **<cluster_name>** is the cluster name and **<base_domain>** is the base domain that you specify in the **install-config.yaml** file. A complete DNS record takes the form: **<component>.<cluster_name>.<base_domain>.**.

Table 17.5. Required DNS records

Component	Record	Description
Kubernetes API	**api.<cluster_name>.<base_domain>.**	A DNS A/AAAA or CNAME record, and a DNS PTR record, to identify the API load balancer. These records must be resolvable by both clients external to the cluster and from all the nodes within the cluster.

Component	Record	Description
	api-int.<cluster_name>. <base_domain>.	A DNS A/AAAA or CNAME record, and a DNS PTR record, to internally identify the API load balancer. These records must be resolvable from all the nodes within the cluster.  **IMPORTANT** The API server must be able to resolve the worker nodes by the hostnames that are recorded in Kubernetes. If the API server cannot resolve the node names, then proxied API calls can fail, and you cannot retrieve logs from pods.
Routes	***.apps.<cluster_name>. <base_domain>.**	A wildcard DNS A/AAAA or CNAME record that refers to the application ingress load balancer. The application ingress load balancer targets the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default. These records must be resolvable by both clients external to the cluster and from all the nodes within the cluster. For example, **console-openshift-console.apps. <cluster_name>.<base_domain>** is used as a wildcard route to the OpenShift Container Platform console.
Bootstrap machine	**bootstrap.<cluster_name>. <base_domain>.**	A DNS A/AAAA or CNAME record, and a DNS PTR record, to identify the bootstrap machine. These records must be resolvable by the nodes within the cluster.
Control plane machines	**<master><n>. <cluster_name>. <base_domain>.**	DNS A/AAAA or CNAME records and DNS PTR records to identify each machine for the control plane nodes. These records must be resolvable by the nodes within the cluster.
Compute machines	**<worker><n>. <cluster_name>. <base_domain>.**	DNS A/AAAA or CNAME records and DNS PTR records to identify each machine for the worker nodes. These records must be resolvable by the nodes within the cluster.



NOTE

In OpenShift Container Platform 4.4 and later, you do not need to specify etcd host and SRV records in your DNS configuration.

TIP

You can use the **dig** command to verify name and reverse name resolution. See the section on *Validating DNS resolution for user-provisioned infrastructure* for detailed validation steps.

17.2.3.11.1. Example DNS configuration for user-provisioned clusters

This section provides A and PTR record configuration samples that meet the DNS requirements for deploying OpenShift Container Platform on user-provisioned infrastructure. The samples are not meant to provide advice for choosing one DNS solution over another.

In the examples, the cluster name is **ocp4** and the base domain is **example.com**.

Example DNS A record configuration for a user-provisioned cluster

The following example is a BIND zone file that shows sample A records for name resolution in a user-provisioned cluster.

Example 17.1. Sample DNS zone database

```
$TTL 1W
@ IN SOA ns1.example.com. root (
  2019070700 ; serial
  3H  ; refresh (3 hours)
  30M  ; retry (30 minutes)
  2W  ; expiry (2 weeks)
  1W )  ; minimum (1 week)
 IN NS ns1.example.com.
 IN MX 10 smtp.example.com.
;
;
ns1.example.com.  IN A 192.168.1.5
smtp.example.com.  IN A 192.168.1.5
;
helper.example.com.  IN A 192.168.1.5
helper.ocp4.example.com. IN A 192.168.1.5
;
api.ocp4.example.com.  IN A 192.168.1.5 1
api-int.ocp4.example.com. IN A 192.168.1.5 2
;
*.apps.ocp4.example.com. IN A 192.168.1.5 3
;
bootstrap.ocp4.example.com. IN A 192.168.1.96 4
;
master0.ocp4.example.com. IN A 192.168.1.97 5
master1.ocp4.example.com. IN A 192.168.1.98 6
master2.ocp4.example.com. IN A 192.168.1.99 7
;
worker0.ocp4.example.com. IN A 192.168.1.11 8
worker1.ocp4.example.com. IN A 192.168.1.7 9
;
;EOF
```

1 Provides name resolution for the Kubernetes API. The record refers to the IP address of the API load balancer.

2 Provides name resolution for the Kubernetes API. The record refers to the IP address of the API load balancer and is used for internal cluster communications.

3 Provides name resolution for the wildcard routes. The record refers to the IP address of the application ingress load balancer. The application ingress load balancer targets the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.

NOTE

In the example, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

4 Provides name resolution for the bootstrap machine.

5 6 7 Provides name resolution for the control plane machines.

8 9 Provides name resolution for the compute machines.

Example DNS PTR record configuration for a user-provisioned cluster

The following example BIND zone file shows sample PTR records for reverse name resolution in a user-provisioned cluster.

Example 17.2. Sample DNS zone database for reverse records

```
$TTL 1W
@ IN SOA ns1.example.com. root (
  2019070700 ; serial
  3H  ; refresh (3 hours)
  30M  ; retry (30 minutes)
  2W  ; expiry (2 weeks)
  1W )  ; minimum (1 week)
 IN NS ns1.example.com.
;
5.1.168.192.in-addr.arpa. IN PTR api.ocp4.example.com. 1
5.1.168.192.in-addr.arpa. IN PTR api-int.ocp4.example.com. 2
;
96.1.168.192.in-addr.arpa. IN PTR bootstrap.ocp4.example.com. 3
;
97.1.168.192.in-addr.arpa. IN PTR master0.ocp4.example.com. 4
98.1.168.192.in-addr.arpa. IN PTR master1.ocp4.example.com. 5
99.1.168.192.in-addr.arpa. IN PTR master2.ocp4.example.com. 6
;
11.1.168.192.in-addr.arpa. IN PTR worker0.ocp4.example.com. 7
7.1.168.192.in-addr.arpa. IN PTR worker1.ocp4.example.com. 8
;
;EOF
```

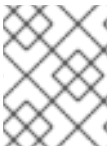
1. Provides reverse DNS resolution for the Kubernetes API. The PTR record refers to the record name of the API load balancer.
2. Provides reverse DNS resolution for the Kubernetes API. The PTR record refers to the record name of the API load balancer and is used for internal cluster communications.
3. Provides reverse DNS resolution for the bootstrap machine.
4 5 6. Provides reverse DNS resolution for the control plane machines.
7 8. Provides reverse DNS resolution for the compute machines.

NOTE

A PTR record is not required for the OpenShift Container Platform application wildcard.

17.2.3.12. Load balancing requirements for user-provisioned infrastructure

Before you install OpenShift Container Platform, you must provision the API and application ingress load balancing infrastructure. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

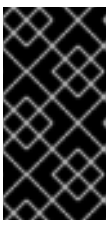


NOTE

If you want to deploy the API and application Ingress load balancers with a Red Hat Enterprise Linux (RHEL) instance, you must purchase the RHEL subscription separately.

The load balancing infrastructure must meet the following requirements:

1. **API load balancer**: Provides a common endpoint for users, both human and machine, to interact with and configure the platform. Configure the following conditions:
   - Layer 4 load balancing only. This can be referred to as Raw TCP, SSL Passthrough, or SSL Bridge mode. If you use SSL Bridge mode, you must enable Server Name Indication (SNI) for the API routes.
   - A stateless load balancing algorithm. The options vary based on the load balancer implementation.



IMPORTANT

Do not configure session persistence for an API load balancer. Configuring session persistence for a Kubernetes API server might cause performance issues from excess application traffic for your OpenShift Container Platform cluster and the Kubernetes API that runs inside the cluster.

Configure the following ports on both the front and back of the load balancers:

Table 17.6. API load balancer

Port	Back-end machines (pool members)	Internal	External	Description
6443	Bootstrap and control plane. You remove the bootstrap machine from the load balancer after the bootstrap machine initializes the cluster control plane. You must configure the **/readyz** endpoint for the API server health check probe.	X	X	Kubernetes API server
22623	Bootstrap and control plane. You remove the bootstrap machine from the load balancer after the bootstrap machine initializes the cluster control plane.	X		Machine config server

NOTE

The load balancer must be configured to take a maximum of 30 seconds from the time the API server turns off the **/readyz** endpoint to the removal of the API server instance from the pool. Within the time frame after **/readyz** returns an error or becomes healthy, the endpoint must have been removed or added. Probing every 5 or 10 seconds, with two successful requests to become healthy and three to become unhealthy, are well-tested values.

2. **Application Ingress load balancer**: Provides an ingress point for application traffic flowing in from outside the cluster. A working configuration for the Ingress router is required for an OpenShift Container Platform cluster.
Configure the following conditions:

   - Layer 4 load balancing only. This can be referred to as Raw TCP, SSL Passthrough, or SSL Bridge mode. If you use SSL Bridge mode, you must enable Server Name Indication (SNI) for the ingress routes.
   - A connection-based or session-based persistence is recommended, based on the options available and types of applications that will be hosted on the platform.

TIP

If the true IP address of the client can be seen by the application Ingress load balancer, enabling source IP-based session persistence can improve performance for applications that use end-to-end TLS encryption.

Configure the following ports on both the front and back of the load balancers:

Table 17.7. Application Ingress load balancer

Port	Back-end machines (pool members)	Internal	External	Description

Port	Back-end machines (pool members)	Internal	External	Description
443	The machines that run the Ingress Controller pods, compute, or worker, by default.	X	X	HTTPS traffic
80	The machines that run the Ingress Controller pods, compute, or worker, by default.	X	X	HTTP traffic

NOTE

If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application Ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes.

17.2.3.12.1. Example load balancer configuration for user-provisioned clusters

This section provides an example API and application ingress load balancer configuration that meets the load balancing requirements for user-provisioned clusters. The sample is an **/etc/haproxy/haproxy.cfg** configuration for an HAProxy load balancer. The example is not meant to provide advice for choosing one load balancing solution over another.

In the example, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

NOTE

If you are using HAProxy as a load balancer and SELinux is set to **enforcing**, you must ensure that the HAProxy service can bind to the configured TCP port by running **setsebool -P haproxy_connect_any=1**.

Example 17.3. Sample API and application Ingress load balancer configuration

```
global
  log         127.0.0.1 local2
  pidfile     /var/run/haproxy.pid
  maxconn     4000
  daemon
defaults
  mode                    http
  log                     global
  option                  dontlognull
  option http-server-close
  option                  redispatch
  retries                 3
  timeout http-request    10s
  timeout queue           1m
  timeout connect         10s
  timeout client          1m
```

```
  timeout server          1m
  timeout http-keep-alive 10s
  timeout check           10s
  maxconn                 3000
listen api-server-6443 1
  bind *:6443
  mode tcp
  server bootstrap bootstrap.ocp4.example.com:6443 check inter 1s backup 2
  server master0 master0.ocp4.example.com:6443 check inter 1s
  server master1 master1.ocp4.example.com:6443 check inter 1s
  server master2 master2.ocp4.example.com:6443 check inter 1s
listen machine-config-server-22623 3
  bind *:22623
  mode tcp
  option  httpchk GET /readyz HTTP/1.0
  option  log-health-checks
  balance roundrobin
  server bootstrap bootstrap.ocp4.example.com:6443 verify none check check-ssl inter 10s fall 2
rise 3 backup 4
  server master0 master0.ocp4.example.com:6443 weight 1 verify none check check-ssl inter 10s
fall 2 rise 3
  server master1 master1.ocp4.example.com:6443 weight 1 verify none check check-ssl inter 10s
fall 2 rise 3
  server master2 master2.ocp4.example.com:6443 weight 1 verify none check check-ssl inter 10s
fall 2 rise 3
listen ingress-router-443 5
  bind *:443
  mode tcp
  balance source
  server worker0 worker0.ocp4.example.com:443 check inter 1s
  server worker1 worker1.ocp4.example.com:443 check inter 1s
listen ingress-router-80 6
  bind *:80
  mode tcp
  balance source
  server worker0 worker0.ocp4.example.com:80 check inter 1s
  server worker1 worker1.ocp4.example.com:80 check inter 1s
```

1. Port **6443** handles the Kubernetes API traffic and points to the control plane machines.

2 4. The bootstrap entries must be in place before the OpenShift Container Platform cluster installation and they must be removed after the bootstrap process is complete.

3. Port **22623** handles the machine config server traffic and points to the control plane machines.

5. Port **443** handles the HTTPS traffic and points to the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.

6. Port **80** handles the HTTP traffic and points to the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.

NOTE

If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application Ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes.

TIP

If you are using HAProxy as a load balancer, you can check that the **haproxy** process is listening on ports **6443**, **22623**, **443**, and **80** by running **netstat -nltupe** on the HAProxy node.

17.2.4. Preparing the user-provisioned infrastructure

Before you install OpenShift Container Platform on user-provisioned infrastructure, you must prepare the underlying infrastructure.

This section provides details about the high-level steps required to set up your cluster infrastructure in preparation for an OpenShift Container Platform installation. This includes configuring IP networking and network connectivity for your cluster nodes, enabling the required ports through your firewall, and setting up the required DNS and load balancing infrastructure.

After preparation, your cluster infrastructure must meet the requirements outlined in the *Requirements for a cluster with user-provisioned infrastructure* section.

Prerequisites

- You have reviewed the OpenShift Container Platform 4.x Tested Integrations page.
- You have reviewed the infrastructure requirements detailed in the *Requirements for a cluster with user-provisioned infrastructure* section.

Procedure

1. If you are using DHCP to provide the IP networking configuration to your cluster nodes, configure your DHCP service.
   a. Add persistent IP addresses for the nodes to your DHCP server configuration. In your configuration, match the MAC address of the relevant network interface to the intended IP address for each node.
   b. When you use DHCP to configure IP addressing for the cluster machines, the machines also obtain the DNS server information through DHCP. Define the persistent DNS server address that is used by the cluster nodes through your DHCP server configuration.

NOTE

If you are not using a DHCP service, you must provide the IP networking configuration and the address of the DNS server to the nodes at RHCOS install time. These can be passed as boot arguments if you are installing from an ISO image. See the *Installing RHCOS and starting the OpenShift Container Platform bootstrap process* section for more information about static IP provisioning and advanced networking options.

c. Define the hostnames of your cluster nodes in your DHCP server configuration. See the *Setting the cluster node hostnames through DHCP* section for details about hostname considerations.

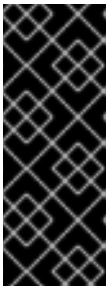
NOTE

If you are not using a DHCP service, the cluster nodes obtain their hostname through a reverse DNS lookup.

2. Choose to perform either a fast track installation of Red Hat Enterprise Linux CoreOS (RHCOS) or a full installation of Red Hat Enterprise Linux CoreOS (RHCOS). For the full installation, you must set up an HTTP or HTTPS server to provide Ignition files and install images to the cluster nodes. For the fast track installation an HTTP or HTTPS server is not required, however, a DHCP server is required. See sections "Fast-track installation: Creating Red Hat Enterprise Linux CoreOS (RHCOS) machines" and "Full installation: Creating Red Hat Enterprise Linux CoreOS (RHCOS) machines".

3. Ensure that your network infrastructure provides the required network connectivity between the cluster components. See the *Networking requirements for user-provisioned infrastructure* section for details about the requirements.

4. Configure your firewall to enable the ports required for the OpenShift Container Platform cluster components to communicate. See *Networking requirements for user-provisioned infrastructure* section for details about the ports that are required.



IMPORTANT

By default, port **1936** is accessible for an OpenShift Container Platform cluster, because each control plane node needs access to this port.

Avoid using the Ingress load balancer to expose this port, because doing so might result in the exposure of sensitive information, such as statistics and metrics, related to Ingress Controllers.

5. Setup the required DNS infrastructure for your cluster.

   a. Configure DNS name resolution for the Kubernetes API, the application wildcard, the bootstrap machine, the control plane machines, and the compute machines.

   b. Configure reverse DNS resolution for the Kubernetes API, the bootstrap machine, the control plane machines, and the compute machines.
   See the *User-provisioned DNS requirements* section for more information about the OpenShift Container Platform DNS requirements.

6. Validate your DNS configuration.

   a. From your installation node, run DNS lookups against the record names of the Kubernetes API, the wildcard routes, and the cluster nodes. Validate that the IP addresses in the responses correspond to the correct components.

   b. From your installation node, run reverse DNS lookups against the IP addresses of the load balancer and the cluster nodes. Validate that the record names in the responses correspond to the correct components.
   See the *Validating DNS resolution for user-provisioned infrastructure* section for detailed DNS validation steps.

7. Provision the required API and application ingress load balancing infrastructure. See the *Load balancing requirements for user-provisioned infrastructure* section for more information about the requirements.

NOTE

Some load balancing solutions require the DNS name resolution for the cluster nodes to be in place before the load balancing is initialized.

17.2.5. Validating DNS resolution for user-provisioned infrastructure

You can validate your DNS configuration before installing OpenShift Container Platform on user-provisioned infrastructure.

IMPORTANT

The validation steps detailed in this section must succeed before you install your cluster.

Prerequisites

- You have configured the required DNS records for your user-provisioned infrastructure.

Procedure

1. From your installation node, run DNS lookups against the record names of the Kubernetes API, the wildcard routes, and the cluster nodes. Validate that the IP addresses contained in the responses correspond to the correct components.

   a. Perform a lookup against the Kubernetes API record name. Check that the result points to the IP address of the API load balancer:

   ```
   $ dig +noall +answer @<nameserver_ip> api.<cluster_name>.<base_domain>
   ```
   (1)

   (1) Replace **<nameserver_ip>** with the IP address of the nameserver, **<cluster_name>** with your cluster name, and **<base_domain>** with your base domain name.

   Example output

   ```
   api.ocp4.example.com.  604800 IN A 192.168.1.5
   ```

   b. Perform a lookup against the Kubernetes internal API record name. Check that the result points to the IP address of the API load balancer:

   ```
   $ dig +noall +answer @<nameserver_ip> api-int.<cluster_name>.<base_domain>
   ```

   Example output

   ```
   api-int.ocp4.example.com.  604800 IN A 192.168.1.5
   ```

   c. Test an example ***.apps.<cluster_name>.<base_domain>** DNS wildcard lookup. All of the application wildcard lookups must resolve to the IP address of the application ingress load balancer:

```
$ dig +noall +answer @<nameserver_ip> random.apps.<cluster_name>.<base_domain>
```

Example output

```
random.apps.ocp4.example.com.  604800 IN A 192.168.1.5
```

NOTE

In the example outputs, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

You can replace **random** with another wildcard value. For example, you can query the route to the OpenShift Container Platform console:

```
$ dig +noall +answer @<nameserver_ip> console-openshift-console.apps.
<cluster_name>.<base_domain>
```

Example output

```
console-openshift-console.apps.ocp4.example.com. 604800 IN A 192.168.1.5
```

d. Run a lookup against the bootstrap DNS record name. Check that the result points to the IP address of the bootstrap node:

```
$ dig +noall +answer @<nameserver_ip> bootstrap.<cluster_name>.<base_domain>
```

Example output

```
bootstrap.ocp4.example.com.  604800 IN A 192.168.1.96
```

e. Use this method to perform lookups against the DNS record names for the control plane and compute nodes. Check that the results correspond to the IP addresses of each node.

2. From your installation node, run reverse DNS lookups against the IP addresses of the load balancer and the cluster nodes. Validate that the record names contained in the responses correspond to the correct components.

a. Perform a reverse lookup against the IP address of the API load balancer. Check that the response includes the record names for the Kubernetes API and the Kubernetes internal API:

```
$ dig +noall +answer @<nameserver_ip> -x 192.168.1.5
```

Example output

```
5.1.168.192.in-addr.arpa. 604800 IN PTR api-int.ocp4.example.com. 1
5.1.168.192.in-addr.arpa. 604800 IN PTR api.ocp4.example.com. 2
```

1. Provides the record name for the Kubernetes internal API.
2. Provides the record name for the Kubernetes API.

NOTE

A PTR record is not required for the OpenShift Container Platform application wildcard. No validation step is needed for reverse DNS resolution against the IP address of the application ingress load balancer.

b. Perform a reverse lookup against the IP address of the bootstrap node. Check that the result points to the DNS record name of the bootstrap node:

```
$ dig +noall +answer @<nameserver_ip> -x 192.168.1.96
```

Example output

```
96.1.168.192.in-addr.arpa. 604800 IN PTR bootstrap.ocp4.example.com.
```

c. Use this method to perform reverse lookups against the IP addresses for the control plane and compute nodes. Check that the results correspond to the DNS record names of each node.

17.2.6. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the ~/**.ssh/authorized_keys** list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The **./openshift-install gather** command also requires the SSH public key to be in place on the cluster nodes.

IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.

Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N '' -f <path>/<file_name>
```
1

1 Specify the path and file name, such as ~/**.ssh/id_ed25519**, of the new SSH key. If you have an existing key pair, ensure your public key is in the your ~/**.ssh** directory.

NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS validated or Modules In Process cryptographic libraries on the **x86_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the ~/**.ssh/id_ed25519.pub** public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the **./openshift-install gather** command.

NOTE

On some distributions, default SSH private key identities such as ~/**.ssh/id_rsa** and ~/**.ssh/id_dsa** are managed automatically.

a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

Example output

```
Agent pid 31874
```

NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

1 Specify the path and file name for your SSH private key, such as ~/**.ssh/id_ed25519**

Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

17.2.7. Obtaining the installation program

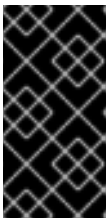
Before you install OpenShift Container Platform, download the installation file on your provisioning machine.

Prerequisites

- You have a machine that runs Linux, for example Red Hat Enterprise Linux 8, with 500 MB of local disk space.

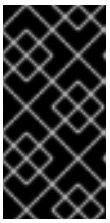
Procedure

1. Access the Infrastructure Provider page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program that corresponds with your host operating system and architecture, and place the file in the directory where you will store the installation configuration files.



IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.



IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation pull secret from the Red Hat OpenShift Cluster Manager . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

17.2.8. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.

IMPORTANT

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.11. Download and install the new version of **oc**.

Installing the OpenShift CLI on Linux
You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the architecture in the **Product Variant** drop-down menu.
3. Select the appropriate version in the **Version** drop-down menu.
4. Click **Download Now** next to the **OpenShift v4.11 Linux Client** entry and save the file.
5. Unpack the archive:

```
$ tar xvf <file>
```

6. Place the **oc** binary in a directory that is on your **PATH**.
   To check your **PATH**, execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

Installing the OpenShift CLI on Windows
You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.

To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
C:\> oc <command>
```

Installing the OpenShift CLI on macOS
You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 macOS Client** entry and save the file.

NOTE

For macOS arm64, choose the **OpenShift v4.11 macOS arm64 Client** entry.

4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your PATH.
   To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

17.2.9. Manually creating the installation configuration file

Prerequisites

- You have an SSH public key on your local machine to provide to the installation program. The key will be used for SSH authentication onto your cluster nodes for debugging and disaster recovery.
- You have obtained the OpenShift Container Platform installation program and the pull secret for your cluster.

Procedure

1. Create an installation directory to store your required installation assets in:

```
$ mkdir <installation_directory>
```

IMPORTANT

You must create a directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

2. Customize the sample **install-config.yaml** file template that is provided and save it in the **<installation_directory>**.

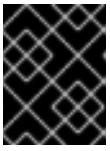
NOTE

You must name this configuration file **install-config.yaml**.

NOTE

For some platform types, you can alternatively run **./openshift-install create install-config --dir <installation_directory>** to generate an **install-config.yaml** file. You can provide details about your cluster configuration at the prompts.

3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.

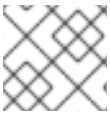


IMPORTANT

The **install-config.yaml** file is consumed during the next step of the installation process. You must back it up now.

17.2.9.1. Installation configuration parameters

Before you deploy an OpenShift Container Platform cluster, you provide a customized **install-config.yaml** installation configuration file that describes the details for your environment.



NOTE

After installation, you cannot modify these parameters in the **install-config.yaml** file.

17.2.9.1.1. Required configuration parameters

Required installation configuration parameters are described in the following table:

Table 17.8. Required parameters

Parameter	Description	Values

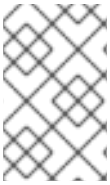
Parameter	Description	Values
apiVersion	The API version for the **install-config.yaml** content. The current version is **v1**. The installer may also support older API versions.	String
baseDomain	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the **baseDomain** and **metadata.name** parameter values that uses the **<metadata.name>.<baseDomain>** format.	A fully-qualified domain or subdomain name, such as **example.com**.
metadata	Kubernetes resource **ObjectMeta**, from which only the **name** parameter is consumed.	Object
metadata.name	The name of the cluster. DNS records for the cluster are all subdomains of **{{.metadata.name}}.{{.baseDomain}}**.	String of lowercase letters, hyphens (**-**), and periods (**.**), such as **dev**.
platform	The configuration for the specific platform upon which to perform the installation: **alibabacloud**, **aws**, **baremetal**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**. For additional information about **platform.<platform>** parameters, consult the table for your specific platform that follows.	Object

Parameter	Description	Values
pullSecret	Get a pull secret from the Red Hat OpenShift Cluster Manager to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	<pre>{ "auths":{ "cloud.openshift.com":{ "auth":"b3Blb=", "email":"you@example.com" }, "quay.io":{ "auth":"b3Blb=", "email":"you@example.com" } } }</pre>

17.2.9.1.2. Network configuration parameters

You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

Only IPv4 addresses are supported.



NOTE

Globalnet is not supported with Red Hat OpenShift Data Foundation disaster recovery solutions. For regional disaster recovery scenarios, ensure that you use a nonoverlapping range of private IP addresses for the cluster and service networks in each cluster.

Table 17.9. Network parameters

Parameter	Description	Values
networking	The configuration for the cluster network.	Object  **NOTE** You cannot modify parameters specified by the **networking** object after installation.

Parameter	Description	Values
networking.networkType	The cluster network provider Container Network Interface (CNI) cluster network provider to install.	Either **OpenShiftSDN** or **OVNKubernetes**. **OpenShiftSDN** is a CNI provider for all-Linux networks. **OVNKubernetes** is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is **OpenShiftSDN**.
networking.clusterNetwork	The IP address blocks for pods. The default value is **10.128.0.0/14** with a host prefix of **/23**. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: networking: clusterNetwork: - cidr: 10.128.0.0/14 hostPrefix: 23
networking.clusterNetwork.cidr	Required if you use **networking.clusterNetwork**. An IP address block. An IPv4 network.	An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between **0** and **32**.
networking.clusterNetwork.hostPrefix	The subnet prefix length to assign to each individual node. For example, if **hostPrefix** is set to **23** then each node is assigned a **/23** subnet out of the given **cidr**. A **hostPrefix** value of **23** provides 510 (2^(32 - 23) - 2) pod IP addresses.	A subnet prefix. The default value is **23**.
networking.serviceNetwork	The IP address block for services. The default value is **172.30.0.0/16**. The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.	An array with an IP address block in CIDR format. For example: networking: serviceNetwork: - 172.30.0.0/16
networking.machineNetwork	The IP address blocks for machines. If you specify multiple IP address blocks, the blocks must not overlap. If you specify multiple IP kernel arguments, the **machineNetwork.cidr** value must be the CIDR of the primary network.	An array of objects. For example: networking: machineNetwork: - cidr: 10.0.0.0/16

Parameter	Description	Values
networking.machineNetwork.cidr	Required if you use **networking.machineNetwork**. An IP address block. The default value is **10.0.0.0/16** for all platforms other than libvirt. For libvirt, the default value is **192.168.126.0/24**.	An IP network block in CIDR notation. For example, **10.0.0.0/16**.  **NOTE** Set the **networking.machineNetwork** to match the CIDR that the preferred NIC resides in.

17.2.9.1.3. Optional configuration parameters

Optional installation configuration parameters are described in the following table:

Table 17.10. Optional parameters

Parameter	Description	Values
additionalTrustBundle	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String
capabilities	Controls the installation of optional core cluster components. You can reduce the footprint of your OpenShift Container Platform cluster by disabling optional components.	String array
capabilities.baselineCapabilitySet	Selects an initial set of optional capabilities to enable. Valid values are **None**, **v4.11** and **vCurrent**. **v4.11** enables the **baremetal** Operator, the **marketplace** Operator, and the **openshift-samples** content. **vCurrent** installs the recommended set of capabilities for the current version of OpenShift Container Platform. The default value is **vCurrent**.	String

Parameter	Description	Values
capabilities.additionalEnabledCapabilities	Extends the set of optional capabilities beyond what you specify in **baselineCapabilitySet**. Valid values are **baremetal**, **marketplace** and **openshift-samples**. You may specify multiple capabilities in this parameter.	String array
cgroupsV2	Enables Linux control groups version 2 (cgroups v2) on specific nodes in your cluster. The OpenShift Container Platform process for enabling cgroups v2 disables all cgroup version 1 controllers and hierarchies. The OpenShift Container Platform cgroups version 2 feature is in Developer Preview and is not supported by Red Hat at this time.	**true**
compute	The configuration for the machines that comprise the compute nodes.	Array of **MachinePool** objects.
compute.architecture	Determines the instruction set architecture of the machines in the pool. Currently, heteregeneous clusters are not supported, so all pools must specify the same architecture. Valid values are **s390x** (the default).	String
compute.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  **IMPORTANT** If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
compute.name	Required if you use **compute**. The name of the machine pool.	**worker**

Parameter	Description	Values
compute.platform	Required if you use **compute**. Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the **controlPlane.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
compute.replicas	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to **2**. The default value is **3**.
controlPlane	The configuration for the machines that comprise the control plane.	Array of **MachinePool** objects.
controlPlane.architecture	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are **s390x** (the default).	String
controlPlane.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  IMPORTANT If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
controlPlane.name	Required if you use **controlPlane**. The name of the machine pool.	**master**
controlPlane.platform	Required if you use **controlPlane**. Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the **compute.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**

Parameter	Description	Values
controlPlane.replicas	The number of control plane machines to provision.	The only supported value is **3**, which is the default value.
credentialsMode	The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported.  **NOTE** Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the *Cloud Credential Operator* entry in the *Cluster Operators reference* content.  **NOTE** If your AWS account has service control policies (SCP) enabled, you must configure the **credentialsMode** parameter to **Mint**, **Passthrough** or **Manual**.	**Mint**, **Passthrough**, **Manual** or an empty string (**""**).

Parameter	Description	Values
fips	Enable or disable FIPS mode. The default is **false** (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.  **IMPORTANT** To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.  **NOTE** If you are using Azure File storage, you cannot enable FIPS mode.	**false** or **true**
imageContentSources	Sources and repositories for the release-image content.	Array of objects. Includes a **source** and, optionally, **mirrors**, as described in the following rows of this table.
imageContentSources.source	Required if you use **imageContentSources**. Specify the repository that users refer to, for example, in image pull specifications.	String

Parameter	Description	Values
imageContentSources.mirrors	Specify one or more repositories that may also contain the same images.	Array of strings
publish	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	**Internal** or **External**. The default value is **External**. Setting this field to **Internal** is not supported on non-cloud platforms and IBM Cloud VPC.  **IMPORTANT** If the value of the field is set to **Internal**, the cluster will become non-functional. For more information, refer to BZ#1953035.
sshKey	The SSH key to authenticate access to your cluster machines.  **NOTE** For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.	For example, **sshKey: ssh-ed25519 AAAA..**.

17.2.9.2. Sample install-config.yaml file for IBM Z

You can customize the **install-config.yaml** file to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.

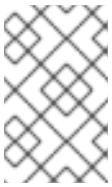
```
apiVersion: v1
baseDomain: example.com (1)
compute: (2)
- hyperthreading: Enabled (3)
  name: worker
  replicas: 0 (4)
  architecture : s390x
controlPlane: (5)
  hyperthreading: Enabled (6)
  name: master
```

```
  replicas: 3 7
  architecture : s390x
metadata:
  name: test 8
networking:
  clusterNetwork:
  - cidr: 10.128.0.0/14 9
    hostPrefix: 23 10
  networkType: OpenShiftSDN
  serviceNetwork: 11
  - 172.30.0.0/16
platform:
  none: {} 12
fips: false 13
pullSecret: '{"auths": ...}' 14
sshKey: 'ssh-ed25519 AAAA...' 15
```

1 The base domain of the cluster. All DNS records must be sub-domains of this base and include the cluster name.

2 5 The **controlPlane** section is a single mapping, but the **compute** section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, **-**, and the first line of the **controlPlane** section must not. Only one control plane pool is used.

3 6 Specifies whether to enable or disable simultaneous multithreading (SMT), or hyperthreading. By default, SMT is enabled to increase the performance of the cores in your machines. You can disable it by setting the parameter value to **Disabled**. If you disable SMT, you must disable it in all cluster machines; this includes both control plane and compute machines.



NOTE

Simultaneous multithreading (SMT) is enabled by default. If SMT is not available on your OpenShift Container Platform nodes, the **hyperthreading** parameter has no effect.

IMPORTANT

If you disable **hyperthreading**, whether on your OpenShift Container Platform nodes or in the **install-config.yaml** file, ensure that your capacity planning accounts for the dramatically decreased machine performance.

4 You must set this value to **0** when you install OpenShift Container Platform on user-provisioned infrastructure. In installer-provisioned installations, the parameter controls the number of compute machines that the cluster creates and manages for you. In user-provisioned installations, you must manually deploy the compute machines before you finish installing the cluster.

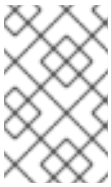
NOTE

If you are installing a three-node cluster, do not deploy any compute machines when you install the Red Hat Enterprise Linux CoreOS (RHCOS) machines.

7 The number of control plane machines that you add to the cluster. Because the cluster uses these

8 The cluster name that you specified in your DNS records.

9 A block of IP addresses from which pod IP addresses are allocated. This block must not overlap with existing physical networks. These IP addresses are used for the pod network. If you need to access the pods from an external network, you must configure load balancers and routers to manage the traffic.



NOTE

Class E CIDR range is reserved for a future use. To use the Class E CIDR range, you must ensure your networking environment accepts the IP addresses within the Class E CIDR range.

10 The subnet prefix length to assign to each individual node. For example, if **hostPrefix** is set to **23**, then each node is assigned a /**23** subnet out of the given **cidr**, which allows for 510 (2^(32 - 23) - 2) pod IP addresses. If you are required to provide access to nodes from an external network, configure load balancers and routers to manage the traffic.

11 The IP address pool to use for service IP addresses. You can enter only one IP address pool. This block must not overlap with existing physical networks. If you need to access the services from an external network, configure load balancers and routers to manage the traffic.

12 You must set the platform to **none**. You cannot provide additional platform configuration variables for IBM Z infrastructure.

IMPORTANT

Clusters that are installed with the platform type **none** are unable to use some features, such as managing compute machines with the Machine API. This limitation applies even if the compute machines that are attached to the cluster are installed on a platform that would normally support the feature. This parameter cannot be changed after installation.

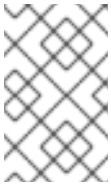
13 Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.

IMPORTANT

To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.

14 The pull secret from the Red Hat OpenShift Cluster Manager . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

15 The SSH public key for the **core** user in Red Hat Enterprise Linux CoreOS (RHCOS).



NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

17.2.9.3. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.

NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
```

1. A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
2. A proxy URL to use for creating HTTPS connections outside the cluster.
3.

A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For

4 If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace that contains one or more additional CA certificates that are required for proxying HTTPS connections. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges these contents with the Red Hat Enterprise Linux CoreOS (RHCOS) trust bundle, and this config map is referenced in the **trustedCA** field of the **Proxy** object. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.

NOTE

The installation program does not support the proxy **readinessEndpoints** field.

NOTE

If the installer times out, restart and then complete the deployment by using the **wait-for** command of the installer. For example:

```
$ ./openshift-install wait-for install-complete --log-level debug
```

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.

NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

17.2.9.4. Configuring a three-node cluster

Optionally, you can deploy zero compute machines in a minimal three node cluster that consists of three control plane machines only. This provides smaller, more resource efficient clusters for cluster administrators and developers to use for testing, development, and production.

In three-node OpenShift Container Platform environments, the three control plane machines are schedulable, which means that your application workloads are scheduled to run on them.

Prerequisites

- You have an existing **install-config.yaml** file.

Procedure

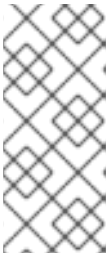
- Ensure that the number of compute replicas is set to **0** in your **install-config.yaml** file, as shown in the following **compute** stanza:

```
compute:
```

```
- name: worker
  platform: {}
  replicas: 0
```

NOTE

You must set the value of the **replicas** parameter for the compute machines to **0** when you install OpenShift Container Platform on user-provisioned infrastructure, regardless of the number of compute machines you are deploying. In installer-provisioned installations, the parameter controls the number of compute machines that the cluster creates and manages for you. This does not apply to user-provisioned installations, where the compute machines are deployed manually.



NOTE

The preferred resource for control plane nodes is six vCPUs and 21 GB. For three control plane nodes this is the memory + vCPU equivalent of a minimum five-node cluster. You should back the three nodes, each installed on a 120 GB disk, with three IFLs that are SMT2 enabled. The minimum tested setup is three vCPUs and 10 GB on a 120 GB disk for each control plane node.

For three-node cluster installations, follow these next steps:

- If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes. See the *Load balancing requirements for user-provisioned infrastructure* section for more information.
- When you create the Kubernetes manifest files in the following procedure, ensure that the **mastersSchedulable** parameter in the **<installation_directory>/manifests/cluster-scheduler-02-config.yml** file is set to **true**. This enables your application workloads to run on the control plane nodes.
- Do not deploy any compute nodes when you create the Red Hat Enterprise Linux CoreOS (RHCOS) machines.

17.2.10. Cluster Network Operator configuration

The configuration for the cluster network is specified as part of the Cluster Network Operator (CNO) configuration and stored in a custom resource (CR) object that is named **cluster**. The CR specifies the fields for the **Network** API in the **operator.openshift.io** API group.

The CNO configuration inherits the following fields during cluster installation from the **Network** API in the **Network.config.openshift.io** API group and these fields cannot be changed:

clusterNetwork

IP address pools from which pod IP addresses are allocated.

serviceNetwork

IP address pool for services.

defaultNetwork.type

Cluster network provider, such as OpenShift SDN or OVN-Kubernetes.

You can specify the cluster network provider configuration for your cluster by setting the fields for the **defaultNetwork** object in the CNO object named **cluster**.

17.2.10.1. Cluster Network Operator configuration object

The fields for the Cluster Network Operator (CNO) are described in the following table:

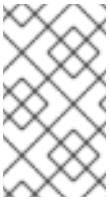
Table 17.11. Cluster Network Operator configuration object

Field	Type	Description
metadata.name	**string**	The name of the CNO object. This name is always **cluster**.
spec.clusterNetwork	**array**	A list specifying the blocks of IP addresses from which pod IP addresses are allocated and the subnet prefix length assigned to each individual node in the cluster. For example: `spec:` `  clusterNetwork:` `  - cidr: 10.128.0.0/19` `  hostPrefix: 23` `  - cidr: 10.128.32.0/19` `  hostPrefix: 23` You can customize this field only in the **install-config.yaml** file before you create the manifests. The value is read-only in the manifest file.
spec.serviceNetwork	**array**	A block of IP addresses for services. The OpenShift SDN and OVN-Kubernetes Container Network Interface (CNI) network providers support only a single IP address block for the service network. For example: `spec:` `  serviceNetwork:` `  - 172.30.0.0/14` You can customize this field only in the **install-config.yaml** file before you create the manifests. The value is read-only in the manifest file.
spec.defaultNetwork	**object**	Configures the Container Network Interface (CNI) cluster network provider for the cluster network.
spec.kubeProxyConfig	**object**	The fields for this object specify the kube-proxy configuration. If you are using the OVN-Kubernetes cluster network provider, the kube-proxy configuration has no effect.

defaultNetwork object configuration

The values for the **defaultNetwork** object are defined in the following table:

Table 17.12. defaultNetwork object

Field	Type	Description
type	**string**	Either **OpenShiftSDN** or **OVNKubernetes**. The cluster network provider is selected during installation. This value cannot be changed after cluster installation.  **NOTE** OpenShift Container Platform uses the OpenShift SDN Container Network Interface (CNI) cluster network provider by default.
openshiftSDNConfig	**object**	This object is only valid for the OpenShift SDN cluster network provider.
ovnKubernetesConfig	**object**	This object is only valid for the OVN-Kubernetes cluster network provider.

Configuration for the OpenShift SDN CNI cluster network provider

The following table describes the configuration fields for the OpenShift SDN Container Network Interface (CNI) cluster network provider.

Table 17.13. **openshiftSDNConfig** object

Field	Type	Description
mode	**string**	Configures the network isolation mode for OpenShift SDN. The default value is **NetworkPolicy**. The values **Multitenant** and **Subnet** are available for backwards compatibility with OpenShift Container Platform 3.x but are not recommended. This value cannot be changed after cluster installation.

Field	Type	Description
mtu	**integer**	The maximum transmission unit (MTU) for the VXLAN overlay network. This is detected automatically based on the MTU of the primary network interface. You do not normally need to override the detected MTU. If the auto-detected value is not what you expect it to be, confirm that the MTU on the primary network interface on your nodes is correct. You cannot use this option to change the MTU value of the primary network interface on the nodes. If your cluster requires different MTU values for different nodes, you must set this value to **50** less than the lowest MTU value in your cluster. For example, if some nodes in your cluster have an MTU of **9001**, and some have an MTU of**1500**, you must set this value to **1450**. This value cannot be changed after cluster installation.
vxlanPort	**integer**	The port to use for all VXLAN packets. The default value is **4789**. This value cannot be changed after cluster installation. If you are running in a virtualized environment with existing nodes that are part of another VXLAN network, then you might be required to change this. For example, when running an OpenShift SDN overlay on top of VMware NSX-T, you must select an alternate port for the VXLAN, because both SDNs use the same default VXLAN port number. On Amazon Web Services (AWS), you can select an alternate port for the VXLAN between port **9000** and port **9999**.

Example OpenShift SDN configuration

```
defaultNetwork:
  type: OpenShiftSDN
  openshiftSDNConfig:
    mode: NetworkPolicy
    mtu: 1450
    vxlanPort: 4789
```

Configuration for the OVN-Kubernetes CNI cluster network provider

The following table describes the configuration fields for the OVN-Kubernetes CNI cluster network provider.

Table 17.14. ovnKubernetesConfig object

Field	Type	Description
mtu	**integer**	The maximum transmission unit (MTU) for the Geneve (Generic Network Virtualization Encapsulation) overlay network. This is detected automatically based on the MTU of the primary network interface. You do not normally need to override the detected MTU. If the auto-detected value is not what you expect it to be, confirm that the MTU on the primary network interface on your nodes is correct. You cannot use this option to change the MTU value of the primary network interface on the nodes. If your cluster requires different MTU values for different nodes, you must set this value to **100** less than the lowest MTU value in your cluster. For example, if some nodes in your cluster have an MTU of **9001**, and some have an MTU of**1500**, you must set this value to **1400**.
genevePort	**integer**	The port to use for all Geneve packets. The default value is **6081**. This value cannot be changed after cluster installation.
ipsecConfig	**object**	Specify an empty object to enable IPsec encryption.
policyAuditConfig	**object**	Specify a configuration object for customizing network policy audit logging. If unset, the defaults audit log settings are used.
gatewayConfig	**object**	Optional: Specify a configuration object for customizing how egress traffic is sent to the node gateway.  NOTE While migrating egress traffic, you can expect some disruption to workloads and service traffic until the Cluster Network Operator (CNO) successfully rolls out the changes.

Table 17.15. **policyAuditConfig** object

Field	Type	Description
rateLimit	integer	The maximum number of messages to generate every second per node. The default value is **20** messages per second.
maxFileSize	integer	The maximum size for the audit log in bytes. The default value is **50000000** or 50 MB.

Field	Type	Description
destination	string	One of the following additional audit log targets: **libc** The libc **syslog()** function of the journald process on the host. **udp:<host>:<port>** A syslog server. Replace **<host>:<port>** with the host and port of the syslog server. **unix:<file>** A Unix Domain Socket file specified by **<file>**. **null** Do not send the audit logs to any additional target.
syslogFacility	string	The syslog facility, such as **kern**, as defined by RFC5424. The default value is **local0**.

Table 17.16. **gatewayConfig** object

Field	Type	Description
routingViaHost	**boolean**	Set this field to **true** to send egress traffic from pods to the host networking stack. For highly-specialized installations and applications that rely on manually configured routes in the kernel routing table, you might want to route egress traffic to the host networking stack. By default, egress traffic is processed in OVN to exit the cluster and is not affected by specialized routes in the kernel routing table. The default value is **false**. This field has an interaction with the Open vSwitch hardware offloading feature. If you set this field to **true**, you do not receive the performance benefits of the offloading because egress traffic is processed by the host networking stack.

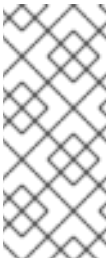
Example OVN-Kubernetes configuration with IPSec enabled

```
defaultNetwork:
  type: OVNKubernetes
  ovnKubernetesConfig:
    mtu: 1400
    genevePort: 6081
    ipsecConfig: {}
```

kubeProxyConfig object configuration

The values for the **kubeProxyConfig** object are defined in the following table:

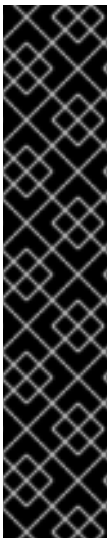
Table 17.17. **kubeProxyConfig** object

Field	Type	Description
iptablesSyncPeriod	**string**	The refresh period for **iptables** rules. The default value is **30s**. Valid suffixes include **s**, **m**, and **h** and are described in the Go **time** package documentation.  **NOTE** Because of performance improvements introduced in OpenShift Container Platform 4.3 and greater, adjusting the **iptablesSyncPeriod** parameter is no longer necessary.
proxyArguments.iptables-min-sync-period	**array**	The minimum duration before refreshing **iptables** rules. This field ensures that the refresh does not happen too frequently. Valid suffixes include **s**, **m**, and **h** and are described in the Go **time** package. The default value is: `kubeProxyConfig:` `  proxyArguments:` `  iptables-min-sync-period:` `  - 0s`

17.2.11. Creating the Kubernetes manifest and Ignition config files

Because you must modify some cluster definition files and manually start the cluster machines, you must generate the Kubernetes manifest and Ignition config files that the cluster needs to configure the machines.

The installation configuration file transforms into the Kubernetes manifests. The manifests wrap into the Ignition configuration files, which are later used to configure the cluster machines.



IMPORTANT

- The Ignition config files that the OpenShift Container Platform installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

NOTE

The installation program that generates the manifest and Ignition files is architecture specific and can be obtained from the client image mirror. The Linux version of the installation program runs on s390x only. This installer program is also available as a Mac OS version.

Prerequisites

- You obtained the OpenShift Container Platform installation program.
- You created the **install-config.yaml** installation configuration file.

Procedure

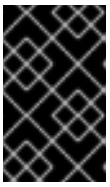
1. Change to the directory that contains the OpenShift Container Platform installation program and generate the Kubernetes manifests for the cluster:

```
$ ./openshift-install create manifests --dir <installation_directory> 1
```

1 For **<installation_directory>**, specify the installation directory that contains the **install-config.yaml** file you created.

WARNING

If you are installing a three-node cluster, skip the following step to allow the control plane nodes to be schedulable.



IMPORTANT

When you configure control plane nodes from the default unschedulable to schedulable, additional subscriptions are required. This is because control plane nodes then become compute nodes.

2. Check that the **mastersSchedulable** parameter in the **<installation_directory>/manifests/cluster-scheduler-02-config.yml** Kubernetes manifest file is set to **false**. This setting prevents pods from being scheduled on the control plane machines:
   a. Open the **<installation_directory>/manifests/cluster-scheduler-02-config.yml** file.
   b. Locate the **mastersSchedulable** parameter and ensure that it is set to **false**.
   c. Save and exit the file.
3. To create the Ignition configuration files, run the following command from the directory that contains the installation program:

```
$ ./openshift-install create ignition-configs --dir <installation_directory> 1
```

1 For **<installation_directory>**, specify the same installation directory.

Ignition config files are created for the bootstrap, control plane, and compute nodes in the installation directory. The **kubeadmin-password** and **kubeconfig** files are created in the **./<installation_directory>/auth** directory:

```
.
├── auth
│   ├── kubeadmin-password
│   └── kubeconfig
├── bootstrap.ign
├── master.ign
├── metadata.json
└── worker.ign
```

17.2.12. Installing RHCOS and starting the OpenShift Container Platform bootstrap process

To install OpenShift Container Platform on IBM Z infrastructure that you provision, you must install Red Hat Enterprise Linux CoreOS (RHCOS) as Red Hat Enterprise Linux (RHEL) guest virtual machines. When you install RHCOS, you must provide the Ignition config file that was generated by the OpenShift Container Platform installation program for the type of machine you are installing. If you have configured suitable networking, DNS, and load balancing infrastructure, the OpenShift Container Platform bootstrap process begins automatically after the RHCOS machines have rebooted.

You can perform a fast-track installation of RHCOS that uses a prepackaged QEMU copy-on-write (QCOW2) disk image. Alternatively, you can perform a full installation on a new QCOW2 disk image.

17.2.12.1. Fast-track installation by using a prepackaged QCOW2 disk image

Complete the following steps to create the machines in a fast-track installation of Red Hat Enterprise Linux CoreOS (RHCOS), importing a prepackaged Red Hat Enterprise Linux CoreOS (RHCOS) QEMU copy-on-write (QCOW2) disk image.

Prerequisites

- At least one LPAR running on RHEL 8.4 or later with KVM, referred to as RHEL KVM host in this procedure.
- The KVM/QEMU hypervisor is installed on the RHEL KVM host.
- A domain name server (DNS) that can perform hostname and reverse lookup for the nodes.
- A DHCP server that provides IP addresses.

Procedure

1. Obtain the RHEL QEMU copy-on-write (QCOW2) disk image file from the Product Downloads page on the Red Hat Customer Portal or from the RHCOS image mirror page.

IMPORTANT

The RHCOS images might not change with every release of OpenShift Container Platform. You must download images with the highest version that is less than or equal to the OpenShift Container Platform version that you install. Only use the appropriate RHCOS QCOW2 image described in the following procedure.

2. Download the QCOW2 disk image and Ignition files to a common directory on the RHEL KVM host.
   For example: **/var/lib/libvirt/images**

NOTE

The Ignition files are generated by the OpenShift Container Platform installer.

3. Create a new disk image with the QCOW2 disk image backing file for each KVM guest node.

```
$ qemu-img create -f qcow2 -F qcow2 -b /var/lib/libvirt/images/{source_rhcos_qemu}
/var/lib/libvirt/images/{vmname}.qcow2 {size}
```

4. Create the new KVM guest nodes using the Ignition file and the new disk image.

```
$ virt-install --noautoconsole \
  --connect qemu:///system \
  --name {vn_name} \
  --memory {memory} \
  --vcpus {vcpus} \
  --disk {disk} \
  --import \
  --network network={network},mac={mac} \
  --disk path={ign_file},format=raw,readonly=on,serial=ignition,startup_policy=optional
```

17.2.12.2. Full installation on a new QCOW2 disk image

Complete the following steps to create the machines in a full installation on a new QEMU copy-on-write (QCOW2) disk image.

Prerequisites

- At least one LPAR running on RHEL 8.4 or later with KVM, referred to as RHEL KVM host in this procedure.
- The KVM/QEMU hypervisor is installed on the RHEL KVM host.
- A domain name server (DNS) that can perform hostname and reverse lookup for the nodes.
- An HTTP or HTTPS server is set up.

Procedure

1. Obtain the RHEL kernel, initramfs, and rootfs files from the Product Downloads page on the Red Hat Customer Portal or from the RHCOS image mirror page.

IMPORTANT

The RHCOS images might not change with every release of OpenShift Container Platform. You must download images with the highest version that is less than or equal to the OpenShift Container Platform version that you install. Only use the appropriate RHCOS QCOW2 image described in the following procedure.

The file names contain the OpenShift Container Platform version number. They resemble the following examples:

- kernel: **rhcos-<version>-live-kernel-<architecture>**
- initramfs: **rhcos-<version>-live-initramfs.<architecture>.img**
- rootfs: **rhcos-<version>-live-rootfs.<architecture>.img**

2. Move the downloaded RHEL live kernel, initramfs, and rootfs as well as the Ignition files to an HTTP or HTTPS server before you launch **virt-install**.

NOTE

The Ignition files are generated by the OpenShift Container Platform installer.

3. Create the new KVM guest nodes using the RHEL kernel, initramfs, and Ignition files, the new disk image, and adjusted parm line arguments.
   - For **--location**, specify the location of the kernel/initrd on the HTTP or HTTPS server.
   - For **coreos.inst.ignition_url=**, specify the Ignition file for the machine role. Use **bootstrap.ign**, **master.ign**, or **worker.ign**. Only HTTP and HTTPS protocols are supported.
   - For **coreos.live.rootfs_url=**, specify the matching rootfs artifact for the kernel and initramfs you are booting. Only HTTP and HTTPS protocols are supported.

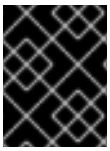
```
$ virt-install \
  --connect qemu:///system \
  --name {vn_name} \
  --vcpus {vcpus} \
  --memory {memory_mb} \
  --disk {vn_name}.qcow2,size={image_size| default(10,true)} \
  --network network={virt_network_parm} \
  --boot hd \
  --location {media_location},kernel={rhcos_kernel},initrd={rhcos_initrd} \
  --extra-args "rd.neednet=1 coreos.inst=yes coreos.inst.install_dev=vda
coreos.live.rootfs_url={rhcos_liveos} ip={ip}::{default_gateway}:{subnet_mask_length}:
{vn_name}:enc1:none:{MTU} nameserver={dns} coreos.inst.ignition_url={rhcos_ign}" \
  --noautoconsole \
  --wait
```

17.2.12.3. Advanced RHCOS installation reference

This section illustrates the networking configuration and other advanced options that allow you to modify the Red Hat Enterprise Linux CoreOS (RHCOS) manual installation process. The following tables describe the kernel arguments and command-line options you can use with the RHCOS live installer and the **coreos-installer** command.

17.2.12.3.1. Networking options for ISO installations

If you install RHCOS from an ISO image, you can add kernel arguments manually when you boot the image to configure networking for a node. If no networking arguments are specified, DHCP is activated in the initramfs when RHCOS detects that networking is required to fetch the Ignition config file.



IMPORTANT

When adding networking arguments manually, you must also add the **rd.neednet=1** kernel argument to bring the network up in the initramfs.

The following information provides examples for configuring networking on your RHCOS nodes for ISO installations. The examples describe how to use the **ip=** and **nameserver=** kernel arguments.

NOTE

Ordering is important when adding the kernel arguments: **ip=** and **nameserver=**.

The networking options are passed to the **dracut** tool during system boot. For more information about the networking options supported by **dracut**, see the **dracut.cmdline** manual page.

The following examples are the networking options for ISO installation.

Configuring DHCP or static IP addresses
To configure an IP address, either use DHCP (**ip=dhcp**) or set an individual static IP address (**ip=<host_ip>**). If setting a static IP, you must then identify the DNS server IP address (**nameserver=<dns_ip>**) on each node. The following example sets:

- The node's IP address to **10.10.10.2**
- The gateway address to **10.10.10.254**
- The netmask to **255.255.255.0**
- The hostname to **core0.example.com**
- The DNS server address to **4.4.4.41**
- The auto-configuration value to **none**. No auto-configuration is required when IP networking is configured statically.

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp1s0:none
nameserver=4.4.4.41
```

NOTE

When you use DHCP to configure IP addressing for the RHCOS machines, the machines also obtain the DNS server information through DHCP. For DHCP-based deployments, you can define the DNS server address that is used by the RHCOS nodes through your DHCP server configuration.

Configuring an IP address without a static hostname

You can configure an IP address without assigning a static hostname. If a static hostname is not set by the user, it will be picked up and automatically set by a reverse DNS lookup. To configure an IP address without a static hostname refer to the following example:

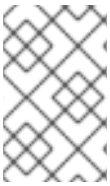
- The node's IP address to **10.10.10.2**
- The gateway address to **10.10.10.254**
- The netmask to **255.255.255.0**
- The DNS server address to **4.4.4.41**
- The auto-configuration value to **none**. No auto-configuration is required when IP networking is configured statically.

```
ip=10.10.10.2::10.10.10.254:255.255.255.0::enp1s0:none
nameserver=4.4.4.41
```

Specifying multiple network interfaces
You can specify multiple network interfaces by setting multiple **ip=** entries.

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp1s0:none
ip=10.10.10.3::10.10.10.254:255.255.255.0:core0.example.com:enp2s0:none
```

Configuring default gateway and route
Optional: You can configure routes to additional networks by setting an **rd.route=** value.



NOTE

When you configure one or multiple networks, one default gateway is required. If the additional network gateway is different from the primary network gateway, the default gateway must be the primary network gateway.

- Run the following command to configure the default gateway:

```
ip=::10.10.10.254::::
```

- Enter the following command to configure the route for the additional network:

```
rd.route=20.20.20.0/24:20.20.20.254:enp2s0
```

Disabling DHCP on a single interface
You can disable DHCP on a single interface, such as when there are two or more network interfaces and only one interface is being used. In the example, the **enp1s0** interface has a static networking configuration and DHCP is disabled for **enp2s0**, which is not used:

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp1s0:none
ip=::::core0.example.com:enp2s0:none
```

Combining DHCP and static IP configurations
You can combine DHCP and static IP configurations on systems with multiple network interfaces, for example:

```
ip=enp1s0:dhcp
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp2s0:none
```

Configuring VLANs on individual interfaces
Optional: You can configure VLANs on individual interfaces by using the **vlan=** parameter.

- To configure a VLAN on a network interface and use a static IP address, run the following command:

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp2s0.100:none
vlan=enp2s0.100:enp2s0
```

- To configure a VLAN on a network interface and to use DHCP, run the following command:

```
ip=enp2s0.100:dhcp
vlan=enp2s0.100:enp2s0
```

Providing multiple DNS servers
You can provide multiple DNS servers by adding a **nameserver=** entry for each server, for example:

```
nameserver=1.1.1.1
nameserver=8.8.8.8
```

17.2.13. Waiting for the bootstrap process to complete

The OpenShift Container Platform bootstrap process begins after the cluster nodes first boot into the persistent RHCOS environment that has been installed to disk. The configuration information provided through the Ignition config files is used to initialize the bootstrap process and install OpenShift Container Platform on the machines. You must wait for the bootstrap process to complete.

Prerequisites

- You have created the Ignition config files for your cluster.
- You have configured suitable network, DNS and load balancing infrastructure.
- You have obtained the installation program and generated the Ignition config files for your cluster.
- You installed RHCOS on your cluster machines and provided the Ignition config files that the OpenShift Container Platform installation program generated.
- Your machines have direct internet access or have an HTTP or HTTPS proxy available.

Procedure

1. Monitor the bootstrap process:

```
$ ./openshift-install --dir <installation_directory> wait-for bootstrap-complete \ 1
    --log-level=info 2
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

Example output

```
INFO Waiting up to 30m0s for the Kubernetes API at https://api.test.example.com:6443...
INFO API v1.24.0 up
INFO Waiting up to 30m0s for bootstrapping to complete...
INFO It is now safe to remove the bootstrap resources
```

The command succeeds when the Kubernetes API server signals that it has been bootstrapped on the control plane machines.

2. After the bootstrap process is complete, remove the bootstrap machine from the load balancer.

IMPORTANT

You must remove the bootstrap machine from the load balancer at this point. You can also remove or reformat the bootstrap machine itself.

17.2.14. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

Example output

```
system:admin
```

17.2.15. Approving the certificate signing requests for your machines

When you add machines to a cluster, two pending certificate signing requests (CSRs) are generated for each machine that you added. You must confirm that these CSRs are approved or, if necessary, approve them yourself. The client requests must be approved first, followed by the server requests.

Prerequisites

- You added machines to your cluster.

Procedure

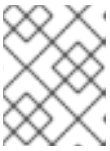
1. Confirm that the cluster recognizes the machines:

```
$ oc get nodes
```

Example output

```
NAME      STATUS    ROLES   AGE  VERSION
master-0  Ready     master  63m  v1.24.0
master-1  Ready     master  63m  v1.24.0
master-2  Ready     master  64m  v1.24.0
```

The output lists all of the machines that you created.



NOTE

The preceding output might not include the compute nodes, also known as worker nodes, until some CSRs are approved.

2. Review the pending CSRs and ensure that you see the client requests with the **Pending** or **Approved** status for each machine that you added to the cluster:

```
$ oc get csr
```

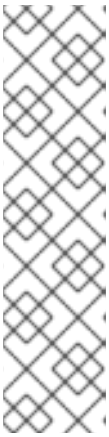
Example output

```
NAME        AGE   REQUESTOR                                   CONDITION
csr-mddf5   20m   system:node:master-01.example.com   Approved,Issued
csr-z5rln   16m   system:node:worker-21.example.com   Approved,Issued
```

3. If the CSRs were not approved, after all of the pending CSRs for the machines you added are in **Pending** status, approve the CSRs for your cluster machines:

NOTE

Because the CSRs rotate automatically, approve your CSRs within an hour of adding the machines to the cluster. If you do not approve them within an hour, the certificates will rotate, and more than two certificates will be present for each node. You must approve all of these certificates. After the client CSR is approved, the Kubelet creates a secondary CSR for the serving certificate, which requires manual approval. Then, subsequent serving certificate renewal requests are automatically approved by the **machine-approver** if the Kubelet requests a new certificate with identical parameters.



NOTE

For clusters running on platforms that are not machine API enabled, such as bare metal and other user-provisioned infrastructure, you must implement a method of automatically approving the kubelet serving certificate requests (CSRs). If a request is not approved, then the **oc exec**, **oc rsh**, and **oc logs** commands cannot succeed, because a serving certificate is required when the API server connects to the kubelet. Any operation that contacts the Kubelet endpoint requires this certificate approval to be in place. The method must watch for new CSRs, confirm that the CSR was submitted by the **node-bootstrapper** service account in the **system:node** or **system:admin** groups, and confirm the identity of the node.

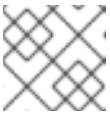
- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

1 **<csr_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{{"\n"}}
{{end}}{{end}}' | xargs --no-run-if-empty oc adm certificate approve
```



NOTE

Some Operators might not become available until some CSRs are approved.

4. Now that your client requests are approved, you must review the server requests for each machine that you added to the cluster:

```
$ oc get csr
```

Example output

```
NAME        AGE    REQUESTOR                                                   CONDITION
csr-bfd72   5m26s  system:node:ip-10-0-50-126.us-east-2.compute.internal
Pending
csr-c57lv   5m26s  system:node:ip-10-0-95-157.us-east-2.compute.internal
Pending
...
```

5. If the remaining CSRs are not approved, and are in the **Pending** status, approve the CSRs for your cluster machines:

- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

1 **<csr_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{{"\n"}}
{{end}}{{end}}' | xargs oc adm certificate approve
```

6. After all client and server CSRs have been approved, the machines have the **Ready** status. Verify this by running the following command:

```
$ oc get nodes
```

Example output

```
NAME      STATUS    ROLES   AGE  VERSION
master-0  Ready     master  73m  v1.24.0
master-1  Ready     master  73m  v1.24.0
master-2  Ready     master  74m  v1.24.0
worker-0  Ready     worker  11m  v1.24.0
worker-1  Ready     worker  11m  v1.24.0
```

NOTE

It can take a few minutes after approval of the server CSRs for the machines to transition to the **Ready** status.

Additional information

- For more information on CSRs, see Certificate Signing Requests.

17.2.16. Initial Operator configuration

After the control plane initializes, you must immediately configure some Operators so that they all become available.

Prerequisites

- Your control plane has initialized.

Procedure

1. Watch the cluster components come online:

```
$ watch -n5 oc get clusteroperators
```

Example output

```
NAME                                       VERSION   AVAILABLE   PROGRESSING   DEGRADED
SINCE
authentication                              4.11.0    True        False         False      19m
baremetal                                  4.11.0    True        False         False      37m
cloud-credential                            4.11.0    True        False         False      40m
cluster-autoscaler                          4.11.0    True        False         False      37m
config-operator                             4.11.0    True        False         False      38m
```

```
console                                    4.11.0    True        False        False      26m
csi-snapshot-controller                    4.11.0    True        False        False      37m
dns                                        4.11.0    True        False        False      37m
etcd                                       4.11.0    True        False        False      36m
image-registry                             4.11.0    True        False        False      31m
ingress                                    4.11.0    True        False        False      30m
insights                                   4.11.0    True        False        False      31m
kube-apiserver                             4.11.0    True        False        False      26m
kube-controller-manager                    4.11.0    True        False        False      36m
kube-scheduler                             4.11.0    True        False        False      36m
kube-storage-version-migrator              4.11.0    True        False        False      37m
machine-api                                4.11.0    True        False        False      29m
machine-approver                           4.11.0    True        False        False      37m
machine-config                             4.11.0    True        False        False      36m
marketplace                                4.11.0    True        False        False      37m
monitoring                                 4.11.0    True        False        False      29m
network                                    4.11.0    True        False        False      38m
node-tuning                                4.11.0    True        False        False      37m
openshift-apiserver                        4.11.0    True        False        False      32m
openshift-controller-manager               4.11.0    True        False        False      30m
openshift-samples                          4.11.0    True        False        False      32m
operator-lifecycle-manager                 4.11.0    True        False        False      37m
operator-lifecycle-manager-catalog         4.11.0    True        False        False      37m
operator-lifecycle-manager-packageserver   4.11.0    True        False        False      32m
service-ca                                 4.11.0    True        False        False      38m
storage                                    4.11.0    True        False        False      37m
```

2. Configure the Operators that are not available.

17.2.16.1. Image registry storage configuration

The Image Registry Operator is not initially available for platforms that do not provide default storage. After installation, you must configure your registry to use storage so that the Registry Operator is made available.

Instructions are shown for configuring a persistent volume, which is required for production clusters. Where applicable, instructions are shown for configuring an empty directory as the storage location, which is available for only non-production clusters.

Additional instructions are provided for allowing the image registry to use block storage types by using the **Recreate** rollout strategy during upgrades.

17.2.16.1.1. Configuring registry storage for IBM Z

As a cluster administrator, following installation you must configure your registry to use storage.

Prerequisites

- You have access to the cluster as a user with the **cluster-admin** role.
- You have a cluster on IBM Z.
- You have provisioned persistent storage for your cluster, such as Red Hat OpenShift Data Foundation.

IMPORTANT

OpenShift Container Platform supports **ReadWriteOnce** access for image registry storage when you have only one replica. **ReadWriteOnce** access also requires that the registry uses the **Recreate** rollout strategy. To deploy an image registry that supports high availability with two or more replicas, **ReadWriteMany** access is required.

- Must have 100Gi capacity.

Procedure

1. To configure your registry to use storage, change the **spec.storage.pvc** in the **configs.imageregistry/cluster** resource.

NOTE

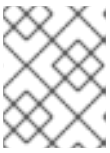
When you use shared storage, review your security settings to prevent outside access.

2. Verify that you do not have a registry pod:

```
$ oc get pod -n openshift-image-registry -l docker-registry=default
```

Example output

```
No resourses found in openshift-image-registry namespace
```



NOTE

If you do have a registry pod in your output, you do not need to continue with this procedure.

3. Check the registry configuration:

```
$ oc edit configs.imageregistry.operator.openshift.io
```

Example output

```
storage:
  pvc:
    claim:
```

Leave the **claim** field blank to allow the automatic creation of an **image-registry-storage** PVC.

4. Check the **clusteroperator** status:

```
$ oc get clusteroperator image-registry
```

Example output

```
NAME              VERSION        AVAILABLE   PROGRESSING   DEGRADED   SINCE
MESSAGE
image-registry    4.11           True        False         False      6h50m
```

5. Ensure that your registry is set to managed to enable building and pushing of images.

   - Run:

     ```
     $ oc edit configs.imageregistry/cluster
     ```

     Then, change the line

     ```
     managementState: Removed
     ```

     to

     ```
     managementState: Managed
     ```

17.2.16.1.2. Configuring storage for the image registry in non-production clusters

You must configure storage for the Image Registry Operator. For non-production clusters, you can set the image registry to an empty directory. If you do so, all images are lost if you restart the registry.

Procedure

- To set the image registry storage to an empty directory:

  ```
  $ oc patch configs.imageregistry.operator.openshift.io cluster --type merge --patch '{"spec":{"storage":{"emptyDir":{}}}}'
  ```

  WARNING

  Configure this option for only non-production clusters.

  If you run this command before the Image Registry Operator initializes its components, the **oc patch** command fails with the following error:

  ```
  Error from server (NotFound): configs.imageregistry.operator.openshift.io "cluster" not found
  ```

  Wait a few minutes and run the command again.

17.2.17. Completing installation on user-provisioned infrastructure

After you complete the Operator configuration, you can finish installing the cluster on infrastructure that you provide.

Prerequisites

- Your control plane has initialized.
- You have completed the initial Operator configuration.

Procedure

1. Confirm that all the cluster components are online with the following command:

```
$ watch -n5 oc get clusteroperators
```

Example output

```
NAME                                       VERSION   AVAILABLE   PROGRESSING   DEGRADED
SINCE
authentication                             4.11.0    True        False         False      19m
baremetal                                  4.11.0    True        False         False      37m
cloud-credential                           4.11.0    True        False         False      40m
cluster-autoscaler                         4.11.0    True        False         False      37m
config-operator                            4.11.0    True        False         False      38m
console                                    4.11.0    True        False         False      26m
csi-snapshot-controller                    4.11.0    True        False         False      37m
dns                                        4.11.0    True        False         False      37m
etcd                                       4.11.0    True        False         False      36m
image-registry                             4.11.0    True        False         False      31m
ingress                                    4.11.0    True        False         False      30m
insights                                   4.11.0    True        False         False      31m
kube-apiserver                             4.11.0    True        False         False      26m
kube-controller-manager                    4.11.0    True        False         False      36m
kube-scheduler                             4.11.0    True        False         False      36m
kube-storage-version-migrator              4.11.0    True        False         False      37m
machine-api                                4.11.0    True        False         False      29m
machine-approver                           4.11.0    True        False         False      37m
machine-config                             4.11.0    True        False         False      36m
marketplace                                4.11.0    True        False         False      37m
monitoring                                 4.11.0    True        False         False      29m
network                                    4.11.0    True        False         False      38m
node-tuning                                4.11.0    True        False         False      37m
openshift-apiserver                        4.11.0    True        False         False      32m
openshift-controller-manager               4.11.0    True        False         False      30m
openshift-samples                          4.11.0    True        False         False      32m
operator-lifecycle-manager                 4.11.0    True        False         False      37m
operator-lifecycle-manager-catalog         4.11.0    True        False         False      37m
operator-lifecycle-manager-packageserver   4.11.0    True        False         False      32m
service-ca                                 4.11.0    True        False         False      38m
storage                                    4.11.0    True        False         False      37m
```

Alternatively, the following command notifies you when all of the clusters are available. It also retrieves and displays credentials:

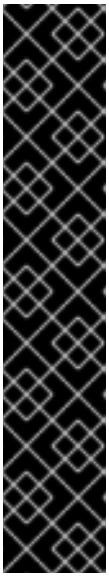
```
$ ./openshift-install --dir <installation_directory> wait-for install-complete 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

Example output

```
INFO Waiting up to 30m0s for the cluster to initialize...
```

The command succeeds when the Cluster Version Operator finishes deploying the OpenShift Container Platform cluster from Kubernetes API server.



IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

2. Confirm that the Kubernetes API server is communicating with the pods.

   a. To view a list of all pods, use the following command:

   ```
   $ oc get pods --all-namespaces
   ```

   Example output

   ```
   NAMESPACE                       NAME                                        READY   STATUS
   RESTARTS   AGE
   openshift-apiserver-operator    openshift-apiserver-operator-85cb746d55-zqhs8   1/1
   Running    1          9m
   openshift-apiserver             apiserver-67b9g                               1/1     Running     0
   3m
   openshift-apiserver             apiserver-ljcmx                               1/1     Running     0
   1m
   openshift-apiserver             apiserver-z25h4                               1/1     Running     0
   2m
   openshift-authentication-operator authentication-operator-69d5d8bf84-vh2n8       1/1
   Running    0          5m
   ...
   ```

   b. View the logs for a pod that is listed in the output of the previous command by using the following command:

   ```
   $ oc logs <pod_name> -n <namespace> 1
   ```

   1 Specify the pod name and namespace, as shown in the output of the previous command.

If the pod logs display, the Kubernetes API server can communicate with the cluster machines.

3. For an installation with Fibre Channel Protocol (FCP), additional steps are required to enable multipathing. Do not enable multipathing during installation.
   See "Enabling multipathing with kernel arguments on RHCOS" in the *Post-installation machine configuration tasks* documentation for more information.

17.2.18. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.11, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to OpenShift Cluster Manager Hybrid Cloud Console.

After you confirm that your OpenShift Cluster Manager Hybrid Cloud Console inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, use subscription watch to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

Additional resources

- See About remote health monitoring for more information about the Telemetry service
- How to generate SOSREPORT within OpenShift4 nodes without SSH .

17.2.19. Next steps

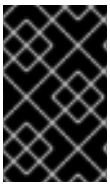
- Customize your cluster.
- If necessary, you can opt out of remote health reporting .

17.3. INSTALLING A CLUSTER WITH RHEL KVM ON IBM Z AND LINUXONE IN A RESTRICTED NETWORK

In OpenShift Container Platform version 4.11, you can install a cluster on IBM Z and LinuxONE infrastructure that you provision in a restricted network.

NOTE

While this document refers to only IBM Z, all information in it also applies to LinuxONE.



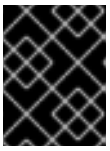
IMPORTANT

Additional considerations exist for non-bare metal platforms. Review the information in the guidelines for deploying OpenShift Container Platform on non-tested platforms before you install an OpenShift Container Platform cluster.

17.3.1. Prerequisites

- You reviewed details about the OpenShift Container Platform installation and update processes.

- You read the documentation on selecting a cluster installation method and preparing it for users.
- You created a registry on your mirror host and obtained the **imageContentSources** data for your version of OpenShift Container Platform.
- You must move or remove any existing installation files, before you begin the installation process. This ensures that the required installation files are created and updated during the installation process.



IMPORTANT

Ensure that installation steps are done from a machine with access to the installation media.

- You provisioned persistent storage using OpenShift Data Foundation or other supported storage protocols for your cluster. To deploy a private image registry, you must set up persistent storage with **ReadWriteMany** access.
- If you use a firewall, you configured it to allow the sites that your cluster requires access to.

NOTE

Be sure to also review this site list if you are configuring a proxy.

- You provisioned a RHEL Kernel Virtual Machine (KVM) system that is hosted on the logical partition (LPAR) and based on RHEL 8.4 or later. See Red Hat Enterprise Linux 8 and 9 Life Cycle.

17.3.2. About installations in restricted networks

In OpenShift Container Platform 4.11, you can perform an installation that does not require an active connection to the internet to obtain software components. Restricted network installations can be completed using installer-provisioned infrastructure or user-provisioned infrastructure, depending on the cloud platform to which you are installing the cluster.

If you choose to perform a restricted network installation on a cloud platform, you still require access to its cloud APIs. Some cloud functions, like Amazon Web Service's Route 53 DNS and IAM services, require internet access. Depending on your network, you might require less internet access for an installation on bare metal hardware or on VMware vSphere.

To complete a restricted network installation, you must create a registry that mirrors the contents of the OpenShift image registry and contains the installation media. You can create this registry on a mirror host, which can access both the internet and your closed network, or by using other methods that meet your restrictions.

IMPORTANT

Because of the complexity of the configuration for user-provisioned installations, consider completing a standard user-provisioned infrastructure installation before you attempt a restricted network installation using user-provisioned infrastructure. Completing this test installation might make it easier to isolate and troubleshoot any issues that might arise during your installation in a restricted network.

17.3.2.1. Additional limits

Clusters in restricted networks have the following additional limitations and restrictions:

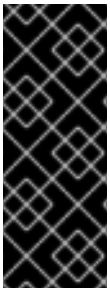
- The **ClusterVersion** status includes an **Unable to retrieve available updates** error.
- By default, you cannot use the contents of the Developer Catalog because you cannot access the required image stream tags.

17.3.3. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.11, you require access to the internet to obtain the images that are necessary to install your cluster.

You must have internet access to:

- Access OpenShift Cluster Manager Hybrid Cloud Console to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access Quay.io to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.



IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

17.3.4. Machine requirements for a cluster with user-provisioned infrastructure

For a cluster that contains user-provisioned infrastructure, you must deploy all of the required machines.

One or more KVM host machines based on RHEL 8.4 or later. Each RHEL KVM host machine must have libvirt installed and running. The virtual machines are provisioned under each RHEL KVM host machine.

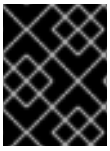
17.3.4.1. Required machines

The smallest OpenShift Container Platform clusters require the following hosts:

Table 17.18. Minimum required hosts

Hosts	Description
One temporary bootstrap machine	The cluster requires the bootstrap machine to deploy the OpenShift Container Platform cluster on the three control plane machines. You can remove the bootstrap machine after you install the cluster.

Hosts	Description
Three control plane machines	The control plane machines run the Kubernetes and OpenShift Container Platform services that form the control plane.
At least two compute machines, which are also known as worker machines.	The workloads requested by OpenShift Container Platform users run on the compute machines.



IMPORTANT

To improve high availability of your cluster, distribute the control plane machines over different RHEL instances on at least two physical machines.

The bootstrap, control plane, and compute machines must use Red Hat Enterprise Linux CoreOS (RHCOS) as the operating system.

See Red Hat Enterprise Linux technology capabilities and limits .

17.3.4.2. Network connectivity requirements

The OpenShift Container Platform installer creates the Ignition files, which are necessary for all the Red Hat Enterprise Linux CoreOS (RHCOS) virtual machines. The automated installation of OpenShift Container Platform is performed by the bootstrap machine. It starts the installation of OpenShift Container Platform on each node, starts the Kubernetes cluster, and then finishes. During this bootstrap, the virtual machine must have an established network connection either through a Dynamic Host Configuration Protocol (DHCP) server or static IP address.

17.3.4.3. IBM Z network connectivity requirements

To install on IBM Z under RHEL KVM, you need:

- A RHEL KVM host configured with an OSA or RoCE network adapter.
- Either a RHEL KVM host that is configured to use bridged networking in libvirt or MacVTap to connect the network to the guests.
  See Types of virtual network connections .

17.3.4.4. Host machine resource requirements

The RHEL KVM host in your environment must meet the following requirements to host the virtual machines that you plan for the OpenShift Container Platform environment. See Getting started with virtualization.

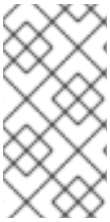
You can install OpenShift Container Platform version 4.11 on the following IBM hardware:

- IBM z16 (all models), IBM z15 (all models), IBM z14 (all models), IBM z13, and IBM z13s
- LinuxONE, any version

17.3.4.5. Minimum IBM Z system environment

Hardware requirements

- The equivalent of six Integrated Facilities for Linux (IFL), which are SMT2 enabled, for each cluster.
- At least one network connection to both connect to the **LoadBalancer** service and to serve data for traffic outside the cluster.



NOTE

You can use dedicated or shared IFLs to assign sufficient compute resources. Resource sharing is one of the key strengths of IBM Z. However, you must adjust capacity correctly on each hypervisor layer and ensure sufficient resources for every OpenShift Container Platform cluster.

IMPORTANT

Since the overall performance of the cluster can be impacted, the LPARs that are used to setup the OpenShift Container Platform clusters must provide sufficient compute capacity. In this context, LPAR weight management, entitlements, and CPU shares on the hypervisor level play an important role.

Operating system requirements

- One LPAR running on RHEL 8.4 or later with KVM, which is managed by libvirt

On your RHEL KVM host, set up:

- Three guest virtual machines for OpenShift Container Platform control plane machines
- Two guest virtual machines for OpenShift Container Platform compute machines
- One guest virtual machine for the temporary OpenShift Container Platform bootstrap machine

17.3.4.6. Minimum resource requirements

Each cluster virtual machine must meet the following minimum requirements:

Virtual Machine	Operating System	vCPU [1]	Virtual RAM	Storage	IOPS
Bootstrap	RHCOS	4	16 GB	100 GB	N/A
Control plane	RHCOS	4	16 GB	100 GB	N/A
Compute	RHCOS	2	8 GB	100 GB	N/A

1. One physical core (IFL) provides two logical cores (threads) when SMT-2 is enabled. The hypervisor can provide two or more vCPUs.

17.3.4.7. Preferred IBM Z system environment

Hardware requirements

- Three LPARS that each have the equivalent of six IFLs, which are SMT2 enabled, for each cluster.
- Two network connections to both connect to the **LoadBalancer** service and to serve data for traffic outside the cluster.

Operating system requirements

- For high availability, two or three LPARs running on RHEL 8.4 or later with KVM, which are managed by libvirt.

On your RHEL KVM host, set up:

- Three guest virtual machines for OpenShift Container Platform control plane machines, distributed across the RHEL KVM host machines.
- At least six guest virtual machines for OpenShift Container Platform compute machines, distributed across the RHEL KVM host machines.
- One guest virtual machine for the temporary OpenShift Container Platform bootstrap machine.
- To ensure the availability of integral components in an overcommitted environment, increase the priority of the control plane by using **cpu_shares**. Do the same for infrastructure nodes, if they exist. See schedinfo in IBM Documentation.

17.3.4.8. Preferred resource requirements

The preferred requirements for each cluster virtual machine are:

Virtual Machine	Operating System	vCPU	Virtual RAM	Storage
Bootstrap	RHCOS	4	16 GB	120 GB
Control plane	RHCOS	8	16 GB	120 GB
Compute	RHCOS	6	8 GB	120 GB

17.3.4.9. Certificate signing requests management

Because your cluster has limited access to automatic machine management when you use infrastructure that you provision, you must provide a mechanism for approving cluster certificate signing requests (CSRs) after installation. The **kube-controller-manager** only approves the kubelet client CSRs. The **machine-approver** cannot guarantee the validity of a serving certificate that is requested by using kubelet credentials because it cannot confirm that the correct machine issued the request. You must determine and implement a method of verifying the validity of the kubelet serving certificate requests and approving them.

Additional resources

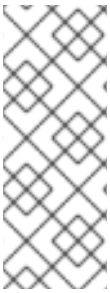
- Recommended host practices for IBM Z & LinuxONE environments

17.3.4.10. Networking requirements for user-provisioned infrastructure

All the Red Hat Enterprise Linux CoreOS (RHCOS) machines require networking to be configured in **initramfs** during boot to fetch their Ignition config files.

During the initial boot, the machines require an IP address configuration that is set either through a DHCP server or statically by providing the required boot options. After a network connection is established, the machines download their Ignition config files from an HTTP or HTTPS server. The Ignition config files are then used to set the exact state of each machine. The Machine Config Operator completes more changes to the machines, such as the application of new certificates or keys, after installation.

It is recommended to use a DHCP server for long-term management of the cluster machines. Ensure that the DHCP server is configured to provide persistent IP addresses, DNS server information, and hostnames to the cluster machines.



NOTE

If a DHCP service is not available for your user-provisioned infrastructure, you can instead provide the IP networking configuration and the address of the DNS server to the nodes at RHCOS install time. These can be passed as boot arguments if you are installing from an ISO image. See the *Installing RHCOS and starting the OpenShift Container Platform bootstrap process* section for more information about static IP provisioning and advanced networking options.

The Kubernetes API server must be able to resolve the node names of the cluster machines. If the API servers and worker nodes are in different zones, you can configure a default DNS search zone to allow the API server to resolve the node names. Another supported approach is to always refer to hosts by their fully-qualified domain names in both the node objects and all DNS requests.

17.3.4.10.1. Setting the cluster node hostnames through DHCP

On Red Hat Enterprise Linux CoreOS (RHCOS) machines, the hostname is set through NetworkManager. By default, the machines obtain their hostname through DHCP. If the hostname is not provided by DHCP, set statically through kernel arguments, or another method, it is obtained through a reverse DNS lookup. Reverse DNS lookup occurs after the network has been initialized on a node and can take time to resolve. Other system services can start prior to this and detect the hostname as **localhost** or similar. You can avoid this by using DHCP to provide the hostname for each cluster node.

Additionally, setting the hostnames through DHCP can bypass any manual DNS record name configuration errors in environments that have a DNS split-horizon implementation.

17.3.4.10.2. Network connectivity requirements

You must configure the network connectivity between machines to allow OpenShift Container Platform cluster components to communicate. Each machine must be able to resolve the hostnames of all other machines in the cluster.

This section provides details about the ports that are required.

Table 17.19. Ports used for all-machine to all-machine communications

Protocol	Port	Description
ICMP	N/A	Network reachability tests
TCP	**1936**	Metrics
	9000-**9999**	Host level services, including the node exporter on ports **9100**-**9101** and the Cluster Version Operator on port**9099**.
	10250-**10259**	The default ports that Kubernetes reserves
	10256	openshift-sdn
UDP	**4789**	VXLAN
	6081	Geneve
	9000-**9999**	Host level services, including the node exporter on ports **9100**-**9101**.
	500	IPsec IKE packets
	4500	IPsec NAT-T packets
TCP/UDP	**30000**-**32767**	Kubernetes node port
ESP	N/A	IPsec Encapsulating Security Payload (ESP)

Table 17.20. Ports used for all-machine to control plane communications

Protocol	Port	Description
TCP	**6443**	Kubernetes API

Table 17.21. Ports used for control plane machine to control plane machine communications

Protocol	Port	Description
TCP	**2379**-**2380**	etcd server and peer ports

NTP configuration for user-provisioned infrastructure

OpenShift Container Platform clusters are configured to use a public Network Time Protocol (NTP) server by default. If you want to use a local enterprise NTP server, or if your cluster is being deployed in a disconnected network, you can configure the cluster to use a specific time server. For more information, see the documentation for *Configuring chrony time service* .

If a DHCP server provides NTP server information, the chrony time service on the Red Hat Enterprise Linux CoreOS (RHCOS) machines read the information and can sync the clock with the NTP servers.

Additional resources

- Configuring chrony time service

17.3.4.11. User-provisioned DNS requirements

In OpenShift Container Platform deployments, DNS name resolution is required for the following components:

- The Kubernetes API
- The OpenShift Container Platform application wildcard
- The bootstrap, control plane, and compute machines

Reverse DNS resolution is also required for the Kubernetes API, the bootstrap machine, the control plane machines, and the compute machines.

DNS A/AAAA or CNAME records are used for name resolution and PTR records are used for reverse name resolution. The reverse records are important because Red Hat Enterprise Linux CoreOS (RHCOS) uses the reverse records to set the hostnames for all the nodes, unless the hostnames are provided by DHCP. Additionally, the reverse records are used to generate the certificate signing requests (CSR) that OpenShift Container Platform needs to operate.

The following DNS records are required for a user-provisioned OpenShift Container Platform cluster and they must be in place before installation. In each record, **<cluster_name>** is the cluster name and **<base_domain>** is the base domain that you specify in the **install-config.yaml** file. A complete DNS record takes the form: **<component>.<cluster_name>.<base_domain>.**.

Table 17.22. Required DNS records

Component	Record	Description
Kubernetes API	**api.<cluster_name>.<base_domain>.**	A DNS A/AAAA or CNAME record, and a DNS PTR record, to identify the API load balancer. These records must be resolvable by both clients external to the cluster and from all the nodes within the cluster.
	api-int.<cluster_name>.<base_domain>.	A DNS A/AAAA or CNAME record, and a DNS PTR record, to internally identify the API load balancer. These records must be resolvable from all the nodes within the cluster. **IMPORTANT** The API server must be able to resolve the worker nodes by the hostnames that are recorded in Kubernetes. If the API server cannot resolve the node names, then proxied API calls can fail, and you cannot retrieve logs from pods.

Component	Record	Description
Routes	***.apps.<cluster_name>. <base_domain>.**	A wildcard DNS A/AAAA or CNAME record that refers to the application ingress load balancer. The application ingress load balancer targets the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default. These records must be resolvable by both clients external to the cluster and from all the nodes within the cluster. For example, **console-openshift-console.apps. <cluster_name>.<base_domain>** is used as a wildcard route to the OpenShift Container Platform console.
Bootstrap machine	**bootstrap.<cluster_name>. <base_domain>.**	A DNS A/AAAA or CNAME record, and a DNS PTR record, to identify the bootstrap machine. These records must be resolvable by the nodes within the cluster.
Control plane machines	**<master><n>. <cluster_name>. <base_domain>.**	DNS A/AAAA or CNAME records and DNS PTR records to identify each machine for the control plane nodes. These records must be resolvable by the nodes within the cluster.
Compute machines	**<worker><n>. <cluster_name>. <base_domain>.**	DNS A/AAAA or CNAME records and DNS PTR records to identify each machine for the worker nodes. These records must be resolvable by the nodes within the cluster.

NOTE

In OpenShift Container Platform 4.4 and later, you do not need to specify etcd host and SRV records in your DNS configuration.

TIP

You can use the **dig** command to verify name and reverse name resolution. See the section on *Validating DNS resolution for user-provisioned infrastructure* for detailed validation steps.

17.3.4.11.1. Example DNS configuration for user-provisioned clusters

This section provides A and PTR record configuration samples that meet the DNS requirements for deploying OpenShift Container Platform on user-provisioned infrastructure. The samples are not meant to provide advice for choosing one DNS solution over another.

In the examples, the cluster name is **ocp4** and the base domain is **example.com**.

Example DNS A record configuration for a user-provisioned cluster

The following example is a BIND zone file that shows sample A records for name resolution in a user-provisioned cluster.

Example 17.4. Sample DNS zone database

```
$TTL 1W
@ IN SOA ns1.example.com. root (
   2019070700 ; serial
   3H  ; refresh (3 hours)
   30M  ; retry (30 minutes)
   2W  ; expiry (2 weeks)
   1W )  ; minimum (1 week)
 IN NS ns1.example.com.
 IN MX 10 smtp.example.com.
;
;
ns1.example.com.  IN A 192.168.1.5
smtp.example.com.  IN A 192.168.1.5
;
helper.example.com.  IN A 192.168.1.5
helper.ocp4.example.com. IN A 192.168.1.5
;
api.ocp4.example.com.  IN A 192.168.1.5 1
api-int.ocp4.example.com. IN A 192.168.1.5 2
;
*.apps.ocp4.example.com. IN A 192.168.1.5 3
;
bootstrap.ocp4.example.com. IN A 192.168.1.96 4
;
master0.ocp4.example.com. IN A 192.168.1.97 5
master1.ocp4.example.com. IN A 192.168.1.98 6
master2.ocp4.example.com. IN A 192.168.1.99 7
;
worker0.ocp4.example.com. IN A 192.168.1.11 8
worker1.ocp4.example.com. IN A 192.168.1.7 9
;
;EOF
```

1. Provides name resolution for the Kubernetes API. The record refers to the IP address of the API load balancer.
2. Provides name resolution for the Kubernetes API. The record refers to the IP address of the API load balancer and is used for internal cluster communications.
3. Provides name resolution for the wildcard routes. The record refers to the IP address of the application ingress load balancer. The application ingress load balancer targets the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.

NOTE

In the example, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

4 Provides name resolution for the bootstrap machine.

5 6 7 Provides name resolution for the control plane machines.

8 9 Provides name resolution for the compute machines.

Example DNS PTR record configuration for a user-provisioned cluster

The following example BIND zone file shows sample PTR records for reverse name resolution in a user-provisioned cluster.

Example 17.5. Sample DNS zone database for reverse records

```
$TTL 1W
@ IN SOA ns1.example.com. root (
  2019070700 ; serial
  3H  ; refresh (3 hours)
  30M  ; retry (30 minutes)
  2W  ; expiry (2 weeks)
  1W )  ; minimum (1 week)
 IN NS ns1.example.com.
;
5.1.168.192.in-addr.arpa. IN PTR api.ocp4.example.com. 1
5.1.168.192.in-addr.arpa. IN PTR api-int.ocp4.example.com. 2
;
96.1.168.192.in-addr.arpa. IN PTR bootstrap.ocp4.example.com. 3
;
97.1.168.192.in-addr.arpa. IN PTR master0.ocp4.example.com. 4
98.1.168.192.in-addr.arpa. IN PTR master1.ocp4.example.com. 5
99.1.168.192.in-addr.arpa. IN PTR master2.ocp4.example.com. 6
;
11.1.168.192.in-addr.arpa. IN PTR worker0.ocp4.example.com. 7
7.1.168.192.in-addr.arpa. IN PTR worker1.ocp4.example.com. 8
;
;EOF
```

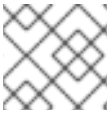
1 Provides reverse DNS resolution for the Kubernetes API. The PTR record refers to the record name of the API load balancer.

2 Provides reverse DNS resolution for the Kubernetes API. The PTR record refers to the record name of the API load balancer and is used for internal cluster communications.

3 Provides reverse DNS resolution for the bootstrap machine.

4 5 6 Provides reverse DNS resolution for the control plane machines.

7 8 Provides reverse DNS resolution for the compute machines.

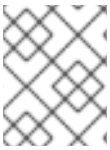


NOTE

A PTR record is not required for the OpenShift Container Platform application wildcard.

17.3.4.12. Load balancing requirements for user-provisioned infrastructure

Before you install OpenShift Container Platform, you must provision the API and application ingress load balancing infrastructure. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.



NOTE

If you want to deploy the API and application Ingress load balancers with a Red Hat Enterprise Linux (RHEL) instance, you must purchase the RHEL subscription separately.

The load balancing infrastructure must meet the following requirements:

1. **API load balancer**: Provides a common endpoint for users, both human and machine, to interact with and configure the platform. Configure the following conditions:

   - Layer 4 load balancing only. This can be referred to as Raw TCP, SSL Passthrough, or SSL Bridge mode. If you use SSL Bridge mode, you must enable Server Name Indication (SNI) for the API routes.
   - A stateless load balancing algorithm. The options vary based on the load balancer implementation.

IMPORTANT

Do not configure session persistence for an API load balancer. Configuring session persistence for a Kubernetes API server might cause performance issues from excess application traffic for your OpenShift Container Platform cluster and the Kubernetes API that runs inside the cluster.

Configure the following ports on both the front and back of the load balancers:

Table 17.23. API load balancer

Port	Back-end machines (pool members)	Internal	External	Description
6443	Bootstrap and control plane. You remove the bootstrap machine from the load balancer after the bootstrap machine initializes the cluster control plane. You must configure the **/readyz** endpoint for the API server health check probe.	X	X	Kubernetes API server
22623	Bootstrap and control plane. You remove the bootstrap machine from the load balancer after the bootstrap machine initializes the cluster control plane.	X		Machine config server

NOTE

The load balancer must be configured to take a maximum of 30 seconds from the time the API server turns off the **/readyz** endpoint to the removal of the API server instance from the pool. Within the time frame after **/readyz** returns an error or becomes healthy, the endpoint must have been removed or added. Probing every 5 or 10 seconds, with two successful requests to become healthy and three to become unhealthy, are well-tested values.

2. **Application Ingress load balancer**: Provides an ingress point for application traffic flowing in from outside the cluster. A working configuration for the Ingress router is required for an OpenShift Container Platform cluster.
Configure the following conditions:

   - Layer 4 load balancing only. This can be referred to as Raw TCP, SSL Passthrough, or SSL Bridge mode. If you use SSL Bridge mode, you must enable Server Name Indication (SNI) for the ingress routes.
   - A connection-based or session-based persistence is recommended, based on the options available and types of applications that will be hosted on the platform.

TIP

If the true IP address of the client can be seen by the application Ingress load balancer, enabling source IP-based session persistence can improve performance for applications that use end-to-end TLS encryption.

Configure the following ports on both the front and back of the load balancers:

Table 17.24. Application Ingress load balancer

Port	Back-end machines (pool members)	Internal	External	Description
443	The machines that run the Ingress Controller pods, compute, or worker, by default.	X	X	HTTPS traffic
80	The machines that run the Ingress Controller pods, compute, or worker, by default.	X	X	HTTP traffic

NOTE

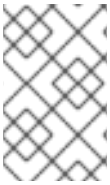
If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application Ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes.

17.3.4.12.1. Example load balancer configuration for user-provisioned clusters

This section provides an example API and application ingress load balancer configuration that meets the load balancing requirements for user-provisioned clusters. The sample is an **/etc/haproxy/haproxy.cfg** configuration for an HAProxy load balancer. The example is not meant to provide advice for choosing

one load balancing solution over another.

In the example, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.



NOTE

If you are using HAProxy as a load balancer and SELinux is set to **enforcing**, you must ensure that the HAProxy service can bind to the configured TCP port by running **setsebool -P haproxy_connect_any=1**.

Example 17.6. Sample API and application Ingress load balancer configuration

```
global
  log         127.0.0.1 local2
  pidfile     /var/run/haproxy.pid
  maxconn     4000
  daemon
defaults
  mode                    http
  log                     global
  option                  dontlognull
  option http-server-close
  option                  redispatch
  retries                 3
  timeout http-request    10s
  timeout queue           1m
  timeout connect         10s
  timeout client          1m
  timeout server          1m
  timeout http-keep-alive 10s
  timeout check           10s
  maxconn                 3000
listen api-server-6443 (1)
  bind *:6443
  mode tcp
  server bootstrap bootstrap.ocp4.example.com:6443 check inter 1s backup (2)
  server master0 master0.ocp4.example.com:6443 check inter 1s
  server master1 master1.ocp4.example.com:6443 check inter 1s
  server master2 master2.ocp4.example.com:6443 check inter 1s
listen machine-config-server-22623 (3)
  bind *:22623
  mode tcp
  option  httpchk GET /readyz HTTP/1.0
  option  log-health-checks
  balance roundrobin
  server bootstrap bootstrap.ocp4.example.com:6443 verify none check check-ssl inter 10s fall 2
rise 3 backup (4)
  server master0 master0.ocp4.example.com:6443 weight 1 verify none check check-ssl inter 10s
fall 2 rise 3
  server master1 master1.ocp4.example.com:6443 weight 1 verify none check check-ssl inter 10s
fall 2 rise 3
  server master2 master2.ocp4.example.com:6443 weight 1 verify none check check-ssl inter 10s
```

```
    fall 2 rise 3
listen ingress-router-443 5
    bind *:443
    mode tcp
    balance source
    server worker0 worker0.ocp4.example.com:443 check inter 1s
    server worker1 worker1.ocp4.example.com:443 check inter 1s
listen ingress-router-80 6
    bind *:80
    mode tcp
    balance source
    server worker0 worker0.ocp4.example.com:80 check inter 1s
    server worker1 worker1.ocp4.example.com:80 check inter 1s
```

1 Port **6443** handles the Kubernetes API traffic and points to the control plane machines.

2 4 The bootstrap entries must be in place before the OpenShift Container Platform cluster installation and they must be removed after the bootstrap process is complete.

3 Port **22623** handles the machine config server traffic and points to the control plane machines.

5 Port **443** handles the HTTPS traffic and points to the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.

6 Port **80** handles the HTTP traffic and points to the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.

NOTE

If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application Ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes.

TIP

If you are using HAProxy as a load balancer, you can check that the **haproxy** process is listening on ports **6443**, **22623**, **443**, and **80** by running **netstat -nltupe** on the HAProxy node.

17.3.5. Preparing the user-provisioned infrastructure

Before you install OpenShift Container Platform on user-provisioned infrastructure, you must prepare the underlying infrastructure.

This section provides details about the high-level steps required to set up your cluster infrastructure in preparation for an OpenShift Container Platform installation. This includes configuring IP networking and network connectivity for your cluster nodes, enabling the required ports through your firewall, and setting up the required DNS and load balancing infrastructure.

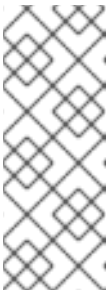
After preparation, your cluster infrastructure must meet the requirements outlined in the *Requirements for a cluster with user-provisioned infrastructure* section.

Prerequisites

- You have reviewed the OpenShift Container Platform 4.x Tested Integrations page.
- You have reviewed the infrastructure requirements detailed in the *Requirements for a cluster with user-provisioned infrastructure* section.

Procedure

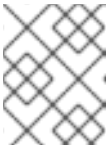
1. If you are using DHCP to provide the IP networking configuration to your cluster nodes, configure your DHCP service.
   a. Add persistent IP addresses for the nodes to your DHCP server configuration. In your configuration, match the MAC address of the relevant network interface to the intended IP address for each node.
   b. When you use DHCP to configure IP addressing for the cluster machines, the machines also obtain the DNS server information through DHCP. Define the persistent DNS server address that is used by the cluster nodes through your DHCP server configuration.



NOTE

If you are not using a DHCP service, you must provide the IP networking configuration and the address of the DNS server to the nodes at RHCOS install time. These can be passed as boot arguments if you are installing from an ISO image. See the *Installing RHCOS and starting the OpenShift Container Platform bootstrap process* section for more information about static IP provisioning and advanced networking options.

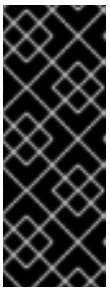
   c. Define the hostnames of your cluster nodes in your DHCP server configuration. See the *Setting the cluster node hostnames through DHCP* section for details about hostname considerations.



NOTE

If you are not using a DHCP service, the cluster nodes obtain their hostname through a reverse DNS lookup.

2. Choose to perform either a fast track installation of Red Hat Enterprise Linux CoreOS (RHCOS) or a full installation of Red Hat Enterprise Linux CoreOS (RHCOS). For the full installation, you must set up an HTTP or HTTPS server to provide Ignition files and install images to the cluster nodes. For the fast track installation an HTTP or HTTPS server is not required, however, a DHCP server is required. See sections “Fast-track installation: Creating Red Hat Enterprise Linux CoreOS (RHCOS) machines" and “Full installation: Creating Red Hat Enterprise Linux CoreOS (RHCOS) machines".
3. Ensure that your network infrastructure provides the required network connectivity between the cluster components. See the *Networking requirements for user-provisioned infrastructure* section for details about the requirements.
4. Configure your firewall to enable the ports required for the OpenShift Container Platform cluster components to communicate. See *Networking requirements for user-provisioned infrastructure* section for details about the ports that are required.



IMPORTANT

By default, port **1936** is accessible for an OpenShift Container Platform cluster, because each control plane node needs access to this port.

Avoid using the Ingress load balancer to expose this port, because doing so might result in the exposure of sensitive information, such as statistics and metrics, related to Ingress Controllers.

5. Setup the required DNS infrastructure for your cluster.

    a. Configure DNS name resolution for the Kubernetes API, the application wildcard, the bootstrap machine, the control plane machines, and the compute machines.

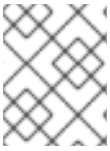
    b. Configure reverse DNS resolution for the Kubernetes API, the bootstrap machine, the control plane machines, and the compute machines.
    See the *User-provisioned DNS requirements* section for more information about the OpenShift Container Platform DNS requirements.

6. Validate your DNS configuration.

    a. From your installation node, run DNS lookups against the record names of the Kubernetes API, the wildcard routes, and the cluster nodes. Validate that the IP addresses in the responses correspond to the correct components.

    b. From your installation node, run reverse DNS lookups against the IP addresses of the load balancer and the cluster nodes. Validate that the record names in the responses correspond to the correct components.
    See the *Validating DNS resolution for user-provisioned infrastructure* section for detailed DNS validation steps.

7. Provision the required API and application ingress load balancing infrastructure. See the *Load balancing requirements for user-provisioned infrastructure* section for more information about the requirements.



NOTE

Some load balancing solutions require the DNS name resolution for the cluster nodes to be in place before the load balancing is initialized.

17.3.6. Validating DNS resolution for user-provisioned infrastructure

You can validate your DNS configuration before installing OpenShift Container Platform on user-provisioned infrastructure.

IMPORTANT

The validation steps detailed in this section must succeed before you install your cluster.

Prerequisites

- You have configured the required DNS records for your user-provisioned infrastructure.

Procedure

1. From your installation node, run DNS lookups against the record names of the Kubernetes API, the wildcard routes, and the cluster nodes. Validate that the IP addresses contained in the responses correspond to the correct components.

   a. Perform a lookup against the Kubernetes API record name. Check that the result points to the IP address of the API load balancer:

   ```
   $ dig +noall +answer @<nameserver_ip> api.<cluster_name>.<base_domain> 1
   ```

   1 Replace **<nameserver_ip>** with the IP address of the nameserver, **<cluster_name>** with your cluster name, and **<base_domain>** with your base domain name.

   Example output

   ```
   api.ocp4.example.com.  604800 IN A 192.168.1.5
   ```

   b. Perform a lookup against the Kubernetes internal API record name. Check that the result points to the IP address of the API load balancer:

   ```
   $ dig +noall +answer @<nameserver_ip> api-int.<cluster_name>.<base_domain>
   ```

   Example output

   ```
   api-int.ocp4.example.com.  604800 IN A 192.168.1.5
   ```

   c. Test an example ***.apps.<cluster_name>.<base_domain>** DNS wildcard lookup. All of the application wildcard lookups must resolve to the IP address of the application ingress load balancer:

   ```
   $ dig +noall +answer @<nameserver_ip> random.apps.<cluster_name>.<base_domain>
   ```

   Example output

   ```
   random.apps.ocp4.example.com.  604800 IN A 192.168.1.5
   ```

   NOTE

   In the example outputs, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

   You can replace **random** with another wildcard value. For example, you can query the route to the OpenShift Container Platform console:

   ```
   $ dig +noall +answer @<nameserver_ip> console-openshift-console.apps.
   <cluster_name>.<base_domain>
   ```

   Example output

   ```
   console-openshift-console.apps.ocp4.example.com. 604800 IN A 192.168.1.5
   ```

d. Run a lookup against the bootstrap DNS record name. Check that the result points to the IP address of the bootstrap node:

```
$ dig +noall +answer @<nameserver_ip> bootstrap.<cluster_name>.<base_domain>
```

Example output

```
bootstrap.ocp4.example.com.  604800 IN A 192.168.1.96
```

e. Use this method to perform lookups against the DNS record names for the control plane and compute nodes. Check that the results correspond to the IP addresses of each node.

2. From your installation node, run reverse DNS lookups against the IP addresses of the load balancer and the cluster nodes. Validate that the record names contained in the responses correspond to the correct components.

a. Perform a reverse lookup against the IP address of the API load balancer. Check that the response includes the record names for the Kubernetes API and the Kubernetes internal API:

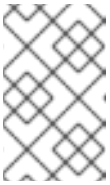
```
$ dig +noall +answer @<nameserver_ip> -x 192.168.1.5
```

Example output

```
5.1.168.192.in-addr.arpa. 604800 IN PTR api-int.ocp4.example.com. 1
5.1.168.192.in-addr.arpa. 604800 IN PTR api.ocp4.example.com. 2
```

1 Provides the record name for the Kubernetes internal API.

2 Provides the record name for the Kubernetes API.



NOTE

A PTR record is not required for the OpenShift Container Platform application wildcard. No validation step is needed for reverse DNS resolution against the IP address of the application ingress load balancer.

b. Perform a reverse lookup against the IP address of the bootstrap node. Check that the result points to the DNS record name of the bootstrap node:

```
$ dig +noall +answer @<nameserver_ip> -x 192.168.1.96
```

Example output

```
96.1.168.192.in-addr.arpa. 604800 IN PTR bootstrap.ocp4.example.com.
```

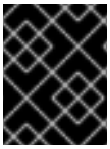
c. Use this method to perform reverse lookups against the IP addresses for the control plane and compute nodes. Check that the results correspond to the DNS record names of each node.

17.3.7. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the **~/.ssh/authorized_keys** list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The **./openshift-install gather** command also requires the SSH public key to be in place on the cluster nodes.



IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.

Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N '' -f <path>/<file_name> 1
```

1 Specify the path and file name, such as **~/.ssh/id_ed25519**, of the new SSH key. If you have an existing key pair, ensure your public key is in the your **~/.ssh** directory.

NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS validated or Modules In Process cryptographic libraries on the **x86_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the **~/.ssh/id_ed25519.pub** public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the **./openshift-install gather** command.

NOTE

On some distributions, default SSH private key identities such as ~/**.ssh/id_rsa** and ~/**.ssh/id_dsa** are managed automatically.

a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

Example output

```
Agent pid 31874
```

NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

1 Specify the path and file name for your SSH private key, such as ~/**.ssh/id_ed25519**

Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

17.3.8. Manually creating the installation configuration file

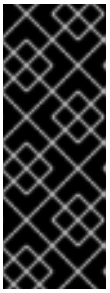
Prerequisites

- You have an SSH public key on your local machine to provide to the installation program. The key will be used for SSH authentication onto your cluster nodes for debugging and disaster recovery.
- You have obtained the OpenShift Container Platform installation program and the pull secret for your cluster.

Procedure

1. Create an installation directory to store your required installation assets in:

```
$ mkdir <installation_directory>
```



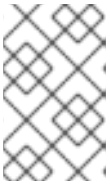
IMPORTANT

You must create a directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

2. Customize the sample **install-config.yaml** file template that is provided and save it in the **<installation_directory>**.

NOTE

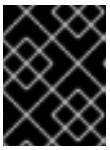
You must name this configuration file **install-config.yaml**.



NOTE

For some platform types, you can alternatively run **./openshift-install create install-config --dir <installation_directory>** to generate an **install-config.yaml** file. You can provide details about your cluster configuration at the prompts.

3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.



IMPORTANT

The **install-config.yaml** file is consumed during the next step of the installation process. You must back it up now.

17.3.8.1. Installation configuration parameters

Before you deploy an OpenShift Container Platform cluster, you provide a customized **install-config.yaml** installation configuration file that describes the details for your environment.

NOTE

After installation, you cannot modify these parameters in the **install-config.yaml** file.

17.3.8.1.1. Required configuration parameters

Required installation configuration parameters are described in the following table:

Table 17.25. Required parameters

Parameter	Description	Values
apiVersion	The API version for the **install-config.yaml** content. The current version is **v1**. The installer may also support older API versions.	String

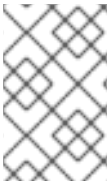
Parameter	Description	Values
baseDomain	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the **baseDomain** and **metadata.name** parameter values that uses the **<metadata.name>.<baseDomain>** format.	A fully-qualified domain or subdomain name, such as **example.com**.
metadata	Kubernetes resource **ObjectMeta**, from which only the **name** parameter is consumed.	Object
metadata.name	The name of the cluster. DNS records for the cluster are all subdomains of **{{.metadata.name}}.{{.baseDomain}}**.	String of lowercase letters, hyphens (**-**), and periods (**.**), such as **dev**.
platform	The configuration for the specific platform upon which to perform the installation: **alibabacloud**, **aws**, **baremetal**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**. For additional information about **platform.<platform>** parameters, consult the table for your specific platform that follows.	Object

Parameter	Description	Values
pullSecret	Get a pull secret from the Red Hat OpenShift Cluster Manager to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	<pre>{ "auths":{ "cloud.openshift.com":{ "auth":"b3Blb=", "email":"you@example.com" }, "quay.io":{ "auth":"b3Blb=", "email":"you@example.com" } } }</pre>

17.3.8.1.2. Network configuration parameters

You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

Only IPv4 addresses are supported.



NOTE

Globalnet is not supported with Red Hat OpenShift Data Foundation disaster recovery solutions. For regional disaster recovery scenarios, ensure that you use a nonoverlapping range of private IP addresses for the cluster and service networks in each cluster.

Table 17.26. Network parameters

Parameter	Description	Values
networking	The configuration for the cluster network.	Object  **NOTE** You cannot modify parameters specified by the **networking** object after installation.

Parameter	Description	Values
networking.networkType	The cluster network provider Container Network Interface (CNI) cluster network provider to install.	Either **OpenShiftSDN** or **OVNKubernetes**. **OpenShiftSDN** is a CNI provider for all-Linux networks. **OVNKubernetes** is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is **OpenShiftSDN**.
networking.clusterNetwork	The IP address blocks for pods. The default value is **10.128.0.0/14** with a host prefix of **/23**. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: `networking:` `  clusterNetwork:` `  - cidr: 10.128.0.0/14` `  hostPrefix: 23`
networking.clusterNetwork.cidr	Required if you use **networking.clusterNetwork**. An IP address block. An IPv4 network.	An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between **0** and **32**.
networking.clusterNetwork.hostPrefix	The subnet prefix length to assign to each individual node. For example, if **hostPrefix** is set to **23** then each node is assigned a **/23** subnet out of the given **cidr**. A **hostPrefix** value of **23** provides 510 (2^(32 - 23) - 2) pod IP addresses.	A subnet prefix. The default value is **23**.
networking.serviceNetwork	The IP address block for services. The default value is **172.30.0.0/16**. The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.	An array with an IP address block in CIDR format. For example: `networking:` `  serviceNetwork:` `  - 172.30.0.0/16`
networking.machineNetwork	The IP address blocks for machines. If you specify multiple IP address blocks, the blocks must not overlap. If you specify multiple IP kernel arguments, the **machineNetwork.cidr** value must be the CIDR of the primary network.	An array of objects. For example: `networking:` `  machineNetwork:` `  - cidr: 10.0.0.0/16`

Parameter	Description	Values
networking.machineNetwork.cidr	Required if you use **networking.machineNetwork**. An IP address block. The default value is **10.0.0.0/16** for all platforms other than libvirt. For libvirt, the default value is **192.168.126.0/24**.	An IP network block in CIDR notation. For example, **10.0.0.0/16**. **NOTE** Set the **networking.machineNetwork** to match the CIDR that the preferred NIC resides in.

17.3.8.1.3. Optional configuration parameters

Optional installation configuration parameters are described in the following table:

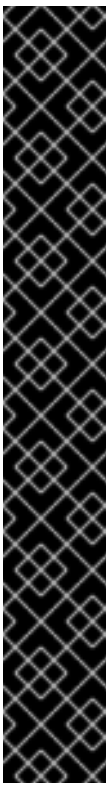
Table 17.27. Optional parameters

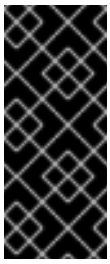
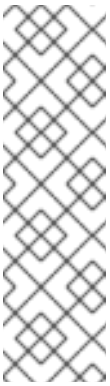
Parameter	Description	Values
additionalTrustBundle	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String
capabilities	Controls the installation of optional core cluster components. You can reduce the footprint of your OpenShift Container Platform cluster by disabling optional components.	String array
capabilities.baselineCapabilitySet	Selects an initial set of optional capabilities to enable. Valid values are **None**, **v4.11** and **vCurrent**. **v4.11** enables the **baremetal** Operator, the **marketplace** Operator, and the **openshift-samples** content. **vCurrent** installs the recommended set of capabilities for the current version of OpenShift Container Platform. The default value is **vCurrent**.	String

Parameter	Description	Values
capabilities.additionalEnabledCapabilities	Extends the set of optional capabilities beyond what you specify in **baselineCapabilitySet**. Valid values are **baremetal**, **marketplace** and **openshift-samples**. You may specify multiple capabilities in this parameter.	String array
cgroupsV2	Enables Linux control groups version 2 (cgroups v2) on specific nodes in your cluster. The OpenShift Container Platform process for enabling cgroups v2 disables all cgroup version 1 controllers and hierarchies. The OpenShift Container Platform cgroups version 2 feature is in Developer Preview and is not supported by Red Hat at this time.	**true**
compute	The configuration for the machines that comprise the compute nodes.	Array of **MachinePool** objects.
compute.architecture	Determines the instruction set architecture of the machines in the pool. Currently, heteregeneous clusters are not supported, so all pools must specify the same architecture. Valid values are **s390x** (the default).	String
compute.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  **IMPORTANT** If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
compute.name	Required if you use **compute**. The name of the machine pool.	**worker**

Parameter	Description	Values
compute.platform	Required if you use **compute**. Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the **controlPlane.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
compute.replicas	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to **2**. The default value is **3**.
controlPlane	The configuration for the machines that comprise the control plane.	Array of **MachinePool** objects.
controlPlane.architecture	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are **s390x** (the default).	String
controlPlane.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  IMPORTANT If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
controlPlane.name	Required if you use **controlPlane**. The name of the machine pool.	**master**
controlPlane.platform	Required if you use **controlPlane**. Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the **compute.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**

Parameter	Description	Values
controlPlane.replicas	The number of control plane machines to provision.	The only supported value is **3**, which is the default value.
credentialsMode	The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported.  **NOTE** Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the *Cloud Credential Operator* entry in the *Cluster Operators reference* content.  **NOTE** If your AWS account has service control policies (SCP) enabled, you must configure the **credentialsMode** parameter to **Mint**, **Passthrough** or **Manual**.	**Mint**, **Passthrough**, **Manual** or an empty string (**""**).

Parameter	Description	Values
fips	Enable or disable FIPS mode. The default is **false** (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.  **IMPORTANT** To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.  **NOTE** If you are using Azure File storage, you cannot enable FIPS mode.	**false** or **true**
imageContentSources	Sources and repositories for the release-image content.	Array of objects. Includes a **source** and, optionally, **mirrors**, as described in the following rows of this table.
imageContentSources.source	Required if you use **imageContentSources**. Specify the repository that users refer to, for example, in image pull specifications.	String

Parameter	Description	Values
imageContentSources.mirrors	Specify one or more repositories that may also contain the same images.	Array of strings
publish	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	**Internal** or **External**. The default value is **External**. Setting this field to **Internal** is not supported on non-cloud platforms and IBM Cloud VPC.  **IMPORTANT** If the value of the field is set to **Internal**, the cluster will become non-functional. For more information, refer to BZ#1953035.
sshKey	The SSH key to authenticate access to your cluster machines.  **NOTE** For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.	For example, **sshKey: ssh-ed25519 AAAA..**.

17.3.8.2. Sample install-config.yaml file for IBM Z

You can customize the **install-config.yaml** file to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.

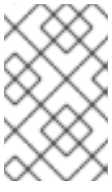
```
apiVersion: v1
baseDomain: example.com (1)
compute: (2)
- hyperthreading: Enabled (3)
  name: worker
  replicas: 0 (4)
  architecture : s390x
controlPlane: (5)
  hyperthreading: Enabled (6)
  name: master
```

```
  replicas: 3 7
  architecture : s390x
metadata:
  name: test 8
networking:
  clusterNetwork:
  - cidr: 10.128.0.0/14 9
    hostPrefix: 23 10
  networkType: OpenShiftSDN
  serviceNetwork: 11
  - 172.30.0.0/16
platform:
  none: {} 12
fips: false 13
pullSecret: '{"auths":{"<local_registry>": {"auth": "<credentials>","email": "you@example.com"}}}' 14
sshKey: 'ssh-ed25519 AAAA...' 15
additionalTrustBundle: | 16
  -----BEGIN CERTIFICATE-----
  ZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZ
  -----END CERTIFICATE-----
imageContentSources: 17
- mirrors:
  - <local_repository>/ocp4/openshift4
  source: quay.io/openshift-release-dev/ocp-release
- mirrors:
  - <local_repository>/ocp4/openshift4
  source: quay.io/openshift-release-dev/ocp-v4.0-art-dev
```

1 The base domain of the cluster. All DNS records must be sub-domains of this base and include the cluster name.

2 5 The **controlPlane** section is a single mapping, but the **compute** section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, **-**, and the first line of the **controlPlane** section must not. Only one control plane pool is used.

3 6 Specifies whether to enable or disable simultaneous multithreading (SMT), or hyperthreading. By default, SMT is enabled to increase the performance of the cores in your machines. You can disable it by setting the parameter value to **Disabled**. If you disable SMT, you must disable it in all cluster machines; this includes both control plane and compute machines.



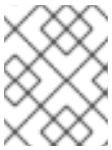
NOTE

Simultaneous multithreading (SMT) is enabled by default. If SMT is not available on your OpenShift Container Platform nodes, the **hyperthreading** parameter has no effect.

IMPORTANT

If you disable **hyperthreading**, whether on your OpenShift Container Platform nodes or in the **install-config.yaml** file, ensure that your capacity planning accounts for the dramatically decreased machine performance.

4 You must set this value to **0** when you install OpenShift Container Platform on user-provisioned infrastructure. In installer-provisioned installations, the parameter controls the number of compute



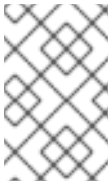
NOTE

If you are installing a three-node cluster, do not deploy any compute machines when you install the Red Hat Enterprise Linux CoreOS (RHCOS) machines.

7 The number of control plane machines that you add to the cluster. Because the cluster uses these values as the number of etcd endpoints in the cluster, the value must match the number of control plane machines that you deploy.

8 The cluster name that you specified in your DNS records.

9 A block of IP addresses from which pod IP addresses are allocated. This block must not overlap with existing physical networks. These IP addresses are used for the pod network. If you need to access the pods from an external network, you must configure load balancers and routers to manage the traffic.



NOTE

Class E CIDR range is reserved for a future use. To use the Class E CIDR range, you must ensure your networking environment accepts the IP addresses within the Class E CIDR range.

10 The subnet prefix length to assign to each individual node. For example, if **hostPrefix** is set to **23**, then each node is assigned a **/23** subnet out of the given **cidr**, which allows for 510 (2^(32 - 23) - 2) pod IP addresses. If you are required to provide access to nodes from an external network, configure load balancers and routers to manage the traffic.

11 The IP address pool to use for service IP addresses. You can enter only one IP address pool. This block must not overlap with existing physical networks. If you need to access the services from an external network, configure load balancers and routers to manage the traffic.

12 You must set the platform to **none**. You cannot provide additional platform configuration variables for IBM Z infrastructure.

IMPORTANT

Clusters that are installed with the platform type **none** are unable to use some features, such as managing compute machines with the Machine API. This limitation applies even if the compute machines that are attached to the cluster are installed on a platform that would normally support the feature. This parameter cannot be changed after installation.

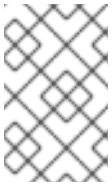
13 Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.

IMPORTANT

To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.

14 For **<local_registry>**, specify the registry domain name, and optionally the port, that your mirror registry uses to serve content. For example, **registry.example.com** or **registry.example.com:5000**. For **<credentials>**, specify the base64-encoded user name and password for your mirror registry.

15 The SSH public key for the **core** user in Red Hat Enterprise Linux CoreOS (RHCOS).



NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

16 Add the **additionalTrustBundle** parameter and value. The value must be the contents of the certificate file that you used for your mirror registry. The certificate file can be an existing, trusted certificate authority or the self-signed certificate that you generated for the mirror registry.

17 Provide the **imageContentSources** section from the output of the command to mirror the repository.

17.3.8.3. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.

NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
```

1. A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
2. A proxy URL to use for creating HTTPS connections outside the cluster.
3. A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use ***** to bypass the proxy for all destinations.
4. If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace that contains one or more additional CA certificates that are required for proxying HTTPS connections. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges these contents with the Red Hat Enterprise Linux CoreOS (RHCOS) trust bundle, and this config map is referenced in the **trustedCA** field of the **Proxy** object. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.

NOTE

The installation program does not support the proxy **readinessEndpoints** field.

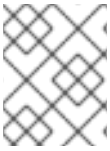
NOTE

If the installer times out, restart and then complete the deployment by using the **wait-for** command of the installer. For example:

```
$ ./openshift-install wait-for install-complete --log-level debug
```

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.



NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

17.3.8.4. Configuring a three-node cluster

Optionally, you can deploy zero compute machines in a minimal three node cluster that consists of three control plane machines only. This provides smaller, more resource efficient clusters for cluster administrators and developers to use for testing, development, and production.

In three-node OpenShift Container Platform environments, the three control plane machines are schedulable, which means that your application workloads are scheduled to run on them.

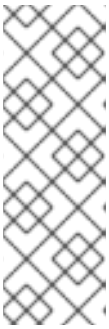
Prerequisites

- You have an existing **install-config.yaml** file.

Procedure

- Ensure that the number of compute replicas is set to **0** in your **install-config.yaml** file, as shown in the following **compute** stanza:

```
compute:
- name: worker
  platform: {}
  replicas: 0
```



NOTE

You must set the value of the **replicas** parameter for the compute machines to **0** when you install OpenShift Container Platform on user-provisioned infrastructure, regardless of the number of compute machines you are deploying. In installer-provisioned installations, the parameter controls the number of compute machines that the cluster creates and manages for you. This does not apply to user-provisioned installations, where the compute machines are deployed manually.

NOTE

The preferred resource for control plane nodes is six vCPUs and 21 GB. For three control plane nodes this is the memory + vCPU equivalent of a minimum five-node cluster. You should back the three nodes, each installed on a 120 GB disk, with three IFLs that are SMT2 enabled. The minimum tested setup is three vCPUs and 10 GB on a 120 GB disk for each control plane node.

For three-node cluster installations, follow these next steps:

- If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes. See the *Load balancing requirements for user-provisioned infrastructure* section for more information.

- When you create the Kubernetes manifest files in the following procedure, ensure that the **mastersSchedulable** parameter in the **<installation_directory>/manifests/cluster-scheduler-02-config.yml** file is set to **true**. This enables your application workloads to run on the control plane nodes.
- Do not deploy any compute nodes when you create the Red Hat Enterprise Linux CoreOS (RHCOS) machines.

17.3.9. Cluster Network Operator configuration

The configuration for the cluster network is specified as part of the Cluster Network Operator (CNO) configuration and stored in a custom resource (CR) object that is named **cluster**. The CR specifies the fields for the **Network** API in the **operator.openshift.io** API group.

The CNO configuration inherits the following fields during cluster installation from the **Network** API in the **Network.config.openshift.io** API group and these fields cannot be changed:

clusterNetwork

IP address pools from which pod IP addresses are allocated.

serviceNetwork

IP address pool for services.

defaultNetwork.type

Cluster network provider, such as OpenShift SDN or OVN-Kubernetes.

You can specify the cluster network provider configuration for your cluster by setting the fields for the **defaultNetwork** object in the CNO object named **cluster**.

17.3.9.1. Cluster Network Operator configuration object

The fields for the Cluster Network Operator (CNO) are described in the following table:

Table 17.28. Cluster Network Operator configuration object

Field	Type	Description
metadata.name	**string**	The name of the CNO object. This name is always **cluster**.
spec.clusterNetwork	**array**	A list specifying the blocks of IP addresses from which pod IP addresses are allocated and the subnet prefix length assigned to each individual node in the cluster. For example: `spec:` `  clusterNetwork:` `  - cidr: 10.128.0.0/19` `  hostPrefix: 23` `  - cidr: 10.128.32.0/19` `  hostPrefix: 23` You can customize this field only in the **install-config.yaml** file before you create the manifests. The value is read-only in the manifest file.

Field	Type	Description
spec.serviceNetwork	**array**	A block of IP addresses for services. The OpenShift SDN and OVN-Kubernetes Container Network Interface (CNI) network providers support only a single IP address block for the service network. For example: `spec:` `  serviceNetwork:` `  - 172.30.0.0/14` You can customize this field only in the **install-config.yaml** file before you create the manifests. The value is read-only in the manifest file.
spec.defaultNetwork	**object**	Configures the Container Network Interface (CNI) cluster network provider for the cluster network.
spec.kubeProxyConfig	**object**	The fields for this object specify the kube-proxy configuration. If you are using the OVN-Kubernetes cluster network provider, the kube-proxy configuration has no effect.

defaultNetwork object configuration

The values for the **defaultNetwork** object are defined in the following table:

Table 17.29. defaultNetwork object

Field	Type	Description
type	**string**	Either **OpenShiftSDN** or **OVNKubernetes**. The cluster network provider is selected during installation. This value cannot be changed after cluster installation.  **NOTE** OpenShift Container Platform uses the OpenShift SDN Container Network Interface (CNI) cluster network provider by default.
openshiftSDNConfig	**object**	This object is only valid for the OpenShift SDN cluster network provider.
ovnKubernetesConfig	**object**	This object is only valid for the OVN-Kubernetes cluster network provider.

Configuration for the OpenShift SDN CNI cluster network provider

The following table describes the configuration fields for the OpenShift SDN Container Network Interface (CNI) cluster network provider.

Table 17.30. openshiftSDNConfig object

Field	Type	Description
mode	**string**	Configures the network isolation mode for OpenShift SDN. The default value is **NetworkPolicy**. The values **Multitenant** and **Subnet** are available for backwards compatibility with OpenShift Container Platform 3.x but are not recommended. This value cannot be changed after cluster installation.
mtu	**integer**	The maximum transmission unit (MTU) for the VXLAN overlay network. This is detected automatically based on the MTU of the primary network interface. You do not normally need to override the detected MTU. If the auto-detected value is not what you expect it to be, confirm that the MTU on the primary network interface on your nodes is correct. You cannot use this option to change the MTU value of the primary network interface on the nodes. If your cluster requires different MTU values for different nodes, you must set this value to **50** less than the lowest MTU value in your cluster. For example, if some nodes in your cluster have an MTU of **9001**, and some have an MTU of**1500**, you must set this value to **1450**. This value cannot be changed after cluster installation.
vxlanPort	**integer**	The port to use for all VXLAN packets. The default value is **4789**. This value cannot be changed after cluster installation. If you are running in a virtualized environment with existing nodes that are part of another VXLAN network, then you might be required to change this. For example, when running an OpenShift SDN overlay on top of VMware NSX-T, you must select an alternate port for the VXLAN, because both SDNs use the same default VXLAN port number. On Amazon Web Services (AWS), you can select an alternate port for the VXLAN between port **9000** and port **9999**.

Example OpenShift SDN configuration

```
defaultNetwork:
  type: OpenShiftSDN
  openshiftSDNConfig:
    mode: NetworkPolicy
    mtu: 1450
    vxlanPort: 4789
```

Configuration for the OVN-Kubernetes CNI cluster network provider

The following table describes the configuration fields for the OVN-Kubernetes CNI cluster network provider.

Table 17.31. **ovnKubernetesConfig** object

Field	Type	Description
mtu	**integer**	The maximum transmission unit (MTU) for the Geneve (Generic Network Virtualization Encapsulation) overlay network. This is detected automatically based on the MTU of the primary network interface. You do not normally need to override the detected MTU. If the auto-detected value is not what you expect it to be, confirm that the MTU on the primary network interface on your nodes is correct. You cannot use this option to change the MTU value of the primary network interface on the nodes. If your cluster requires different MTU values for different nodes, you must set this value to **100** less than the lowest MTU value in your cluster. For example, if some nodes in your cluster have an MTU of **9001**, and some have an MTU of**1500**, you must set this value to **1400**.
genevePort	**integer**	The port to use for all Geneve packets. The default value is **6081**. This value cannot be changed after cluster installation.
ipsecConfig	**object**	Specify an empty object to enable IPsec encryption.
policyAuditConfig	**object**	Specify a configuration object for customizing network policy audit logging. If unset, the defaults audit log settings are used.
gatewayConfig	**object**	Optional: Specify a configuration object for customizing how egress traffic is sent to the node gateway.  NOTE While migrating egress traffic, you can expect some disruption to workloads and service traffic until the Cluster Network Operator (CNO) successfully rolls out the changes.

Table 17.32. **policyAuditConfig** object

Field	Type	Description
rateLimit	integer	The maximum number of messages to generate every second per node. The default value is **20** messages per second.

Field	Type	Description
maxFileSize	integer	The maximum size for the audit log in bytes. The default value is **50000000** or 50 MB.
destination	string	One of the following additional audit log targets: **libc** The libc **syslog()** function of the journald process on the host. **udp:<host>:<port>** A syslog server. Replace **<host>:<port>** with the host and port of the syslog server. **unix:<file>** A Unix Domain Socket file specified by **<file>**. **null** Do not send the audit logs to any additional target.
syslogFacility	string	The syslog facility, such as **kern**, as defined by RFC5424. The default value is **local0**.

Table 17.33. **gatewayConfig** object

Field	Type	Description
routingViaHost	**boolean**	Set this field to **true** to send egress traffic from pods to the host networking stack. For highly-specialized installations and applications that rely on manually configured routes in the kernel routing table, you might want to route egress traffic to the host networking stack. By default, egress traffic is processed in OVN to exit the cluster and is not affected by specialized routes in the kernel routing table. The default value is **false**. This field has an interaction with the Open vSwitch hardware offloading feature. If you set this field to **true**, you do not receive the performance benefits of the offloading because egress traffic is processed by the host networking stack.

Example OVN-Kubernetes configuration with IPSec enabled

```
defaultNetwork:
  type: OVNKubernetes
  ovnKubernetesConfig:
    mtu: 1400
    genevePort: 6081
    ipsecConfig: {}
```

kubeProxyConfig object configuration
The values for the **kubeProxyConfig** object are defined in the following table:

Table 17.34. **kubeProxyConfig** object

Field	Type	Description
iptablesSyncPeriod	**string**	The refresh period for **iptables** rules. The default value is **30s**. Valid suffixes include **s**, **m**, and **h** and are described in the Go **time** package documentation.  **NOTE** Because of performance improvements introduced in OpenShift Container Platform 4.3 and greater, adjusting the **iptablesSyncPeriod** parameter is no longer necessary.
proxyArguments.iptables-min-sync-period	**array**	The minimum duration before refreshing **iptables** rules. This field ensures that the refresh does not happen too frequently. Valid suffixes include **s**, **m**, and **h** and are described in the Go **time** package. The default value is: `kubeProxyConfig:` `  proxyArguments:` `  iptables-min-sync-period:` `  - 0s`

17.3.10. Creating the Kubernetes manifest and Ignition config files

Because you must modify some cluster definition files and manually start the cluster machines, you must generate the Kubernetes manifest and Ignition config files that the cluster needs to configure the machines.

The installation configuration file transforms into the Kubernetes manifests. The manifests wrap into the Ignition configuration files, which are later used to configure the cluster machines.

IMPORTANT

- The Ignition config files that the OpenShift Container Platform installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

NOTE

The installation program that generates the manifest and Ignition files is architecture specific and can be obtained from the client image mirror. The Linux version of the installation program runs on s390x only. This installer program is also available as a Mac OS version.

Prerequisites

- You obtained the OpenShift Container Platform installation program. For a restricted network installation, these files are on your mirror host.
- You created the **install-config.yaml** installation configuration file.

Procedure

1. Change to the directory that contains the OpenShift Container Platform installation program and generate the Kubernetes manifests for the cluster:

```
$ ./openshift-install create manifests --dir <installation_directory> 1
```

1 For **<installation_directory>**, specify the installation directory that contains the **install-config.yaml** file you created.

WARNING

If you are installing a three-node cluster, skip the following step to allow the control plane nodes to be schedulable.

IMPORTANT

When you configure control plane nodes from the default unschedulable to schedulable, additional subscriptions are required. This is because control plane nodes then become compute nodes.

2. Check that the **mastersSchedulable** parameter in the **<installation_directory>/manifests/cluster-scheduler-02-config.yml** Kubernetes manifest file is set to **false**. This setting prevents pods from being scheduled on the control plane machines:
   a. Open the **<installation_directory>/manifests/cluster-scheduler-02-config.yml** file.
   b. Locate the **mastersSchedulable** parameter and ensure that it is set to **false**.
   c. Save and exit the file.
3. To create the Ignition configuration files, run the following command from the directory that contains the installation program:

```
$ ./openshift-install create ignition-configs --dir <installation_directory> 1
```

1 For **<installation_directory>**, specify the same installation directory.

Ignition config files are created for the bootstrap, control plane, and compute nodes in the installation directory. The **kubeadmin-password** and **kubeconfig** files are created in the **./<installation_directory>/auth** directory:

```
.
├── auth
│   ├── kubeadmin-password
│   └── kubeconfig
├── bootstrap.ign
├── master.ign
├── metadata.json
└── worker.ign
```

17.3.11. Installing RHCOS and starting the OpenShift Container Platform bootstrap process

To install OpenShift Container Platform on IBM Z infrastructure that you provision, you must install Red Hat Enterprise Linux CoreOS (RHCOS) as Red Hat Enterprise Linux (RHEL) guest virtual machines. When you install RHCOS, you must provide the Ignition config file that was generated by the OpenShift Container Platform installation program for the type of machine you are installing. If you have configured suitable networking, DNS, and load balancing infrastructure, the OpenShift Container Platform bootstrap process begins automatically after the RHCOS machines have rebooted.

You can perform a fast-track installation of RHCOS that uses a prepackaged QEMU copy-on-write (QCOW2) disk image. Alternatively, you can perform a full installation on a new QCOW2 disk image.

17.3.11.1. Fast-track installation by using a prepackaged QCOW2 disk image

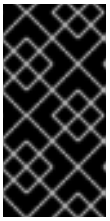
Complete the following steps to create the machines in a fast-track installation of Red Hat Enterprise Linux CoreOS (RHCOS), importing a prepackaged Red Hat Enterprise Linux CoreOS (RHCOS) QEMU copy-on-write (QCOW2) disk image.

Prerequisites

- At least one LPAR running on RHEL 8.4 or later with KVM, referred to as RHEL KVM host in this procedure.
- The KVM/QEMU hypervisor is installed on the RHEL KVM host.
- A domain name server (DNS) that can perform hostname and reverse lookup for the nodes.
- A DHCP server that provides IP addresses.

Procedure

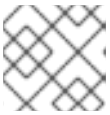
1. Obtain the RHEL QEMU copy-on-write (QCOW2) disk image file from the Product Downloads page on the Red Hat Customer Portal or from the RHCOS image mirror page.



IMPORTANT

The RHCOS images might not change with every release of OpenShift Container Platform. You must download images with the highest version that is less than or equal to the OpenShift Container Platform version that you install. Only use the appropriate RHCOS QCOW2 image described in the following procedure.

2. Download the QCOW2 disk image and Ignition files to a common directory on the RHEL KVM host.
   For example: **/var/lib/libvirt/images**



NOTE

The Ignition files are generated by the OpenShift Container Platform installer.

3. Create a new disk image with the QCOW2 disk image backing file for each KVM guest node.

```
$ qemu-img create -f qcow2 -F qcow2 -b /var/lib/libvirt/images/{source_rhcos_qemu}
/var/lib/libvirt/images/{vmname}.qcow2 {size}
```

4. Create the new KVM guest nodes using the Ignition file and the new disk image.

```
$ virt-install --noautoconsole \
  --connect qemu:///system \
  --name {vn_name} \
  --memory {memory} \
  --vcpus {vcpus} \
  --disk {disk} \
  --import \
  --network network={network},mac={mac} \
  --disk path={ign_file},format=raw,readonly=on,serial=ignition,startup_policy=optional
```

17.3.11.2. Full installation on a new QCOW2 disk image

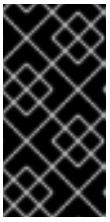
Complete the following steps to create the machines in a full installation on a new QEMU copy-on-write (QCOW2) disk image.

Prerequisites

- At least one LPAR running on RHEL 8.4 or later with KVM, referred to as RHEL KVM host in this procedure.
- The KVM/QEMU hypervisor is installed on the RHEL KVM host.
- A domain name server (DNS) that can perform hostname and reverse lookup for the nodes.
- An HTTP or HTTPS server is set up.

Procedure

1. Obtain the RHEL kernel, initramfs, and rootfs files from the Product Downloads page on the Red Hat Customer Portal or from the RHCOS image mirror page.



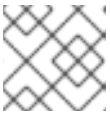
IMPORTANT

The RHCOS images might not change with every release of OpenShift Container Platform. You must download images with the highest version that is less than or equal to the OpenShift Container Platform version that you install. Only use the appropriate RHCOS QCOW2 image described in the following procedure.

The file names contain the OpenShift Container Platform version number. They resemble the following examples:

- kernel: **rhcos-<version>-live-kernel-<architecture>**
- initramfs: **rhcos-<version>-live-initramfs.<architecture>.img**
- rootfs: **rhcos-<version>-live-rootfs.<architecture>.img**

2. Move the downloaded RHEL live kernel, initramfs, and rootfs as well as the Ignition files to an HTTP or HTTPS server before you launch **virt-install**.



NOTE

The Ignition files are generated by the OpenShift Container Platform installer.

3. Create the new KVM guest nodes using the RHEL kernel, initramfs, and Ignition files, the new disk image, and adjusted parm line arguments.
   - For **--location**, specify the location of the kernel/initrd on the HTTP or HTTPS server.
   - For **coreos.inst.ignition_url=**, specify the Ignition file for the machine role. Use **bootstrap.ign**, **master.ign**, or **worker.ign**. Only HTTP and HTTPS protocols are supported.
   - For **coreos.live.rootfs_url=**, specify the matching rootfs artifact for the kernel and initramfs you are booting. Only HTTP and HTTPS protocols are supported.

```
$ virt-install \
  --connect qemu:///system \
  --name {vn_name} \
  --vcpus {vcpus} \
  --memory {memory_mb} \
  --disk {vn_name}.qcow2,size={image_size| default(10,true)} \
  --network network={virt_network_parm} \
  --boot hd \
  --location {media_location},kernel={rhcos_kernel},initrd={rhcos_initrd} \
  --extra-args "rd.neednet=1 coreos.inst=yes coreos.inst.install_dev=vda
coreos.live.rootfs_url={rhcos_liveos} ip={ip}::{default_gateway}:{subnet_mask_length}:
{vn_name}:enc1:none:{MTU} nameserver={dns} coreos.inst.ignition_url={rhcos_ign}" \
  --noautoconsole \
  --wait
```

17.3.11.3. Advanced RHCOS installation reference

This section illustrates the networking configuration and other advanced options that allow you to modify the Red Hat Enterprise Linux CoreOS (RHCOS) manual installation process. The following tables describe the kernel arguments and command-line options you can use with the RHCOS live installer and the **coreos-installer** command.

17.3.11.3.1. Networking options for ISO installations

If you install RHCOS from an ISO image, you can add kernel arguments manually when you boot the image to configure networking for a node. If no networking arguments are specified, DHCP is activated in the initramfs when RHCOS detects that networking is required to fetch the Ignition config file.

IMPORTANT

When adding networking arguments manually, you must also add the **rd.neednet=1** kernel argument to bring the network up in the initramfs.

The following information provides examples for configuring networking on your RHCOS nodes for ISO installations. The examples describe how to use the **ip=** and **nameserver=** kernel arguments.

NOTE

Ordering is important when adding the kernel arguments: **ip=** and **nameserver=**.

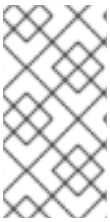
The networking options are passed to the **dracut** tool during system boot. For more information about the networking options supported by **dracut**, see the **dracut.cmdline** manual page.

The following examples are the networking options for ISO installation.

Configuring DHCP or static IP addresses
To configure an IP address, either use DHCP (**ip=dhcp**) or set an individual static IP address (**ip=<host_ip>**). If setting a static IP, you must then identify the DNS server IP address (**nameserver=<dns_ip>**) on each node. The following example sets:

- The node's IP address to **10.10.10.2**
- The gateway address to **10.10.10.254**
- The netmask to **255.255.255.0**
- The hostname to **core0.example.com**
- The DNS server address to **4.4.4.41**
- The auto-configuration value to **none**. No auto-configuration is required when IP networking is configured statically.

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp1s0:none
nameserver=4.4.4.41
```



NOTE

When you use DHCP to configure IP addressing for the RHCOS machines, the machines also obtain the DNS server information through DHCP. For DHCP-based deployments, you can define the DNS server address that is used by the RHCOS nodes through your DHCP server configuration.

Configuring an IP address without a static hostname

You can configure an IP address without assigning a static hostname. If a static hostname is not set by the user, it will be picked up and automatically set by a reverse DNS lookup. To configure an IP address without a static hostname refer to the following example:

- The node's IP address to **10.10.10.2**
- The gateway address to **10.10.10.254**
- The netmask to **255.255.255.0**
- The DNS server address to **4.4.4.41**
- The auto-configuration value to **none**. No auto-configuration is required when IP networking is configured statically.

```
ip=10.10.10.2::10.10.10.254:255.255.255.0::enp1s0:none
nameserver=4.4.4.41
```

Specifying multiple network interfaces
You can specify multiple network interfaces by setting multiple **ip=** entries.

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp1s0:none
ip=10.10.10.3::10.10.10.254:255.255.255.0:core0.example.com:enp2s0:none
```

Configuring default gateway and route
Optional: You can configure routes to additional networks by setting an **rd.route=** value.

NOTE

When you configure one or multiple networks, one default gateway is required. If the additional network gateway is different from the primary network gateway, the default gateway must be the primary network gateway.

- Run the following command to configure the default gateway:

```
ip=::10.10.10.254::::
```

- Enter the following command to configure the route for the additional network:

```
rd.route=20.20.20.0/24:20.20.20.254:enp2s0
```

Disabling DHCP on a single interface
You can disable DHCP on a single interface, such as when there are two or more network interfaces and only one interface is being used. In the example, the **enp1s0** interface has a static networking configuration and DHCP is disabled for **enp2s0**, which is not used:

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp1s0:none
ip=::::core0.example.com:enp2s0:none
```

Combining DHCP and static IP configurations
You can combine DHCP and static IP configurations on systems with multiple network interfaces, for example:

```
ip=enp1s0:dhcp
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp2s0:none
```

Configuring VLANs on individual interfaces
Optional: You can configure VLANs on individual interfaces by using the **vlan=** parameter.

- To configure a VLAN on a network interface and use a static IP address, run the following command:

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp2s0.100:none
vlan=enp2s0.100:enp2s0
```

- To configure a VLAN on a network interface and to use DHCP, run the following command:

```
ip=enp2s0.100:dhcp
vlan=enp2s0.100:enp2s0
```

Providing multiple DNS servers
You can provide multiple DNS servers by adding a **nameserver=** entry for each server, for example:

```
nameserver=1.1.1.1
nameserver=8.8.8.8
```

17.3.12. Waiting for the bootstrap process to complete

The OpenShift Container Platform bootstrap process begins after the cluster nodes first boot into the persistent RHCOS environment that has been installed to disk. The configuration information provided through the Ignition config files is used to initialize the bootstrap process and install OpenShift Container Platform on the machines. You must wait for the bootstrap process to complete.

Prerequisites

- You have created the Ignition config files for your cluster.
- You have configured suitable network, DNS and load balancing infrastructure.
- You have obtained the installation program and generated the Ignition config files for your cluster.
- You installed RHCOS on your cluster machines and provided the Ignition config files that the OpenShift Container Platform installation program generated.

Procedure

1. Monitor the bootstrap process:

```
$ ./openshift-install --dir <installation_directory> wait-for bootstrap-complete \ 1
    --log-level=info 2
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

Example output

```
INFO Waiting up to 30m0s for the Kubernetes API at https://api.test.example.com:6443...
INFO API v1.24.0 up
INFO Waiting up to 30m0s for bootstrapping to complete...
INFO It is now safe to remove the bootstrap resources
```

The command succeeds when the Kubernetes API server signals that it has been bootstrapped on the control plane machines.

2. After the bootstrap process is complete, remove the bootstrap machine from the load balancer.

IMPORTANT

You must remove the bootstrap machine from the load balancer at this point. You can also remove or reformat the bootstrap machine itself.

17.3.13. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

Example output

```
system:admin
```

17.3.14. Approving the certificate signing requests for your machines

When you add machines to a cluster, two pending certificate signing requests (CSRs) are generated for each machine that you added. You must confirm that these CSRs are approved or, if necessary, approve them yourself. The client requests must be approved first, followed by the server requests.

Prerequisites

- You added machines to your cluster.

Procedure

1. Confirm that the cluster recognizes the machines:

```
$ oc get nodes
```

Example output

```
NAME      STATUS    ROLES   AGE  VERSION
master-0  Ready     master  63m  v1.24.0
master-1  Ready     master  63m  v1.24.0
master-2  Ready     master  64m  v1.24.0
```

The output lists all of the machines that you created.

NOTE

The preceding output might not include the compute nodes, also known as worker nodes, until some CSRs are approved.

2. Review the pending CSRs and ensure that you see the client requests with the **Pending** or **Approved** status for each machine that you added to the cluster:

```
$ oc get csr
```

Example output

```
NAME        AGE     REQUESTOR                                                   CONDITION
csr-8b2br   15m     system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper   Pending
csr-8vnps   15m     system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper   Pending
...
```

In this example, two machines are joining the cluster. You might see more approved CSRs in the list.

3. If the CSRs were not approved, after all of the pending CSRs for the machines you added are in **Pending** status, approve the CSRs for your cluster machines:

NOTE

Because the CSRs rotate automatically, approve your CSRs within an hour of adding the machines to the cluster. If you do not approve them within an hour, the certificates will rotate, and more than two certificates will be present for each node. You must approve all of these certificates. After the client CSR is approved, the Kubelet creates a secondary CSR for the serving certificate, which requires manual approval. Then, subsequent serving certificate renewal requests are automatically approved by the **machine-approver** if the Kubelet requests a new certificate with identical parameters.

NOTE

For clusters running on platforms that are not machine API enabled, such as bare metal and other user-provisioned infrastructure, you must implement a method of automatically approving the kubelet serving certificate requests (CSRs). If a request is not approved, then the **oc exec**, **oc rsh**, and **oc logs** commands cannot succeed, because a serving certificate is required when the API server connects to the kubelet. Any operation that contacts the Kubelet endpoint requires this certificate approval to be in place. The method must watch for new CSRs, confirm that the CSR was submitted by the **node-bootstrapper** service account in the **system:node** or **system:admin** groups, and confirm the identity of the node.

- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

1 **<csr_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{{"\n"}}
{{end}}{{end}}' | xargs --no-run-if-empty oc adm certificate approve
```

NOTE

Some Operators might not become available until some CSRs are approved.

4. Now that your client requests are approved, you must review the server requests for each machine that you added to the cluster:

```
$ oc get csr
```

Example output

```
NAME        AGE     REQUESTOR                                                   CONDITION
csr-bfd72   5m26s   system:node:ip-10-0-50-126.us-east-2.compute.internal
Pending
csr-c57lv   5m26s   system:node:ip-10-0-95-157.us-east-2.compute.internal
Pending
...
```

5. If the remaining CSRs are not approved, and are in the **Pending** status, approve the CSRs for your cluster machines:

   - To approve them individually, run the following command for each valid CSR:

     ```
     $ oc adm certificate approve <csr_name> 1
     ```

     1 **<csr_name>** is the name of a CSR from the list of current CSRs.

   - To approve all pending CSRs, run the following command:

     ```
     $ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{{"\n"}}
     {{end}}{{end}}' | xargs oc adm certificate approve
     ```

6. After all client and server CSRs have been approved, the machines have the **Ready** status. Verify this by running the following command:

   ```
   $ oc get nodes
   ```

   Example output

   ```
   NAME      STATUS    ROLES   AGE  VERSION
   master-0  Ready     master  73m  v1.24.0
   master-1  Ready     master  73m  v1.24.0
   master-2  Ready     master  74m  v1.24.0
   worker-0  Ready     worker  11m  v1.24.0
   worker-1  Ready     worker  11m  v1.24.0
   ```

   NOTE

   It can take a few minutes after approval of the server CSRs for the machines to transition to the **Ready** status.

Additional information

- For more information on CSRs, see Certificate Signing Requests.

17.3.15. Initial Operator configuration

After the control plane initializes, you must immediately configure some Operators so that they all become available.

Prerequisites

- Your control plane has initialized.

Procedure

1. Watch the cluster components come online:

   ```
   $ watch -n5 oc get clusteroperators
   ```

Example output

```
NAME                                       VERSION   AVAILABLE   PROGRESSING   DEGRADED
SINCE
authentication                             4.11.0    True        False         False      19m
baremetal                                  4.11.0    True        False         False      37m
cloud-credential                           4.11.0    True        False         False      40m
cluster-autoscaler                         4.11.0    True        False         False      37m
config-operator                            4.11.0    True        False         False      38m
console                                    4.11.0    True        False         False      26m
csi-snapshot-controller                    4.11.0    True        False         False      37m
dns                                        4.11.0    True        False         False      37m
etcd                                       4.11.0    True        False         False      36m
image-registry                             4.11.0    True        False         False      31m
ingress                                    4.11.0    True        False         False      30m
insights                                   4.11.0    True        False         False      31m
kube-apiserver                             4.11.0    True        False         False      26m
kube-controller-manager                    4.11.0    True        False         False      36m
kube-scheduler                             4.11.0    True        False         False      36m
kube-storage-version-migrator              4.11.0    True        False         False      37m
machine-api                                4.11.0    True        False         False      29m
machine-approver                           4.11.0    True        False         False      37m
machine-config                             4.11.0    True        False         False      36m
marketplace                                4.11.0    True        False         False      37m
monitoring                                 4.11.0    True        False         False      29m
network                                    4.11.0    True        False         False      38m
node-tuning                                4.11.0    True        False         False      37m
openshift-apiserver                        4.11.0    True        False         False      32m
openshift-controller-manager               4.11.0    True        False         False      30m
openshift-samples                          4.11.0    True        False         False      32m
operator-lifecycle-manager                 4.11.0    True        False         False      37m
operator-lifecycle-manager-catalog         4.11.0    True        False         False      37m
operator-lifecycle-manager-packageserver   4.11.0    True        False         False      32m
service-ca                                 4.11.0    True        False         False      38m
storage                                    4.11.0    True        False         False      37m
```

2. Configure the Operators that are not available.

17.3.15.1. Disabling the default OperatorHub sources

Operator catalogs that source content provided by Red Hat and community projects are configured for OperatorHub by default during an OpenShift Container Platform installation. In a restricted network environment, you must disable the default catalogs as a cluster administrator.

Procedure

- Disable the sources for the default catalogs by adding **disableAllDefaultSources: true** to the **OperatorHub** object:

```
$ oc patch OperatorHub cluster --type json \
    -p '[{"op": "add", "path": "/spec/disableAllDefaultSources", "value": true}]'
```

TIP

Alternatively, you can use the web console to manage catalog sources. From the **Administration → Cluster Settings → Configuration → OperatorHub** page, click the **Sources** tab, where you can create, update, delete, disable, and enable individual sources.

17.3.15.2. Image registry storage configuration

The Image Registry Operator is not initially available for platforms that do not provide default storage. After installation, you must configure your registry to use storage so that the Registry Operator is made available.

Instructions are shown for configuring a persistent volume, which is required for production clusters. Where applicable, instructions are shown for configuring an empty directory as the storage location, which is available for only non-production clusters.

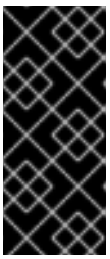
Additional instructions are provided for allowing the image registry to use block storage types by using the **Recreate** rollout strategy during upgrades.

17.3.15.2.1. Configuring registry storage for IBM Z

As a cluster administrator, following installation you must configure your registry to use storage.

Prerequisites

- You have access to the cluster as a user with the **cluster-admin** role.
- You have a cluster on IBM Z.
- You have provisioned persistent storage for your cluster, such as Red Hat OpenShift Data Foundation.



IMPORTANT

OpenShift Container Platform supports **ReadWriteOnce** access for image registry storage when you have only one replica. **ReadWriteOnce** access also requires that the registry uses the **Recreate** rollout strategy. To deploy an image registry that supports high availability with two or more replicas, **ReadWriteMany** access is required.

- Must have 100Gi capacity.

Procedure

1. To configure your registry to use storage, change the **spec.storage.pvc** in the **configs.imageregistry/cluster** resource.

NOTE

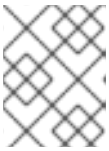
When you use shared storage, review your security settings to prevent outside access.

2. Verify that you do not have a registry pod:

```
$ oc get pod -n openshift-image-registry -l docker-registry=default
```

Example output

```
No resourses found in openshift-image-registry namespace
```



NOTE

If you do have a registry pod in your output, you do not need to continue with this procedure.

3. Check the registry configuration:

```
$ oc edit configs.imageregistry.operator.openshift.io
```

Example output

```
storage:
  pvc:
    claim:
```

Leave the **claim** field blank to allow the automatic creation of an **image-registry-storage** PVC.

4. Check the **clusteroperator** status:

```
$ oc get clusteroperator image-registry
```

Example output

```
NAME              VERSION       AVAILABLE   PROGRESSING   DEGRADED   SINCE
MESSAGE
image-registry    4.11          True        False         False      6h50m
```

5. Ensure that your registry is set to managed to enable building and pushing of images.

- Run:

```
$ oc edit configs.imageregistry/cluster
```

Then, change the line

```
managementState: Removed
```

to

```
managementState: Managed
```

17.3.15.2.2. Configuring storage for the image registry in non-production clusters

You must configure storage for the Image Registry Operator. For non-production clusters, you can set the image registry to an empty directory. If you do so, all images are lost if you restart the registry.

Procedure

- To set the image registry storage to an empty directory:

```
$ oc patch configs.imageregistry.operator.openshift.io cluster --type merge --patch '{"spec":{"storage":{"emptyDir":{}}}}'
```

> **WARNING**
>
> Configure this option for only non-production clusters.

If you run this command before the Image Registry Operator initializes its components, the **oc patch** command fails with the following error:

```
Error from server (NotFound): configs.imageregistry.operator.openshift.io "cluster" not found
```

Wait a few minutes and run the command again.

17.3.16. Completing installation on user-provisioned infrastructure

After you complete the Operator configuration, you can finish installing the cluster on infrastructure that you provide.

Prerequisites

- Your control plane has initialized.
- You have completed the initial Operator configuration.

Procedure

1. Confirm that all the cluster components are online with the following command:

```
$ watch -n5 oc get clusteroperators
```

Example output

```
NAME                                       VERSION   AVAILABLE   PROGRESSING   DEGRADED   SINCE
authentication                             4.11.0    True        False         False      19m
baremetal                                  4.11.0    True        False         False      37m
cloud-credential                           4.11.0    True        False         False      40m
cluster-autoscaler                         4.11.0    True        False         False      37m
config-operator                            4.11.0    True        False         False      38m
console                                    4.11.0    True        False         False      26m
csi-snapshot-controller                    4.11.0    True        False         False      37m
dns                                        4.11.0    True        False         False      37m
etcd                                       4.11.0    True        False         False      36m
image-registry                             4.11.0    True        False         False      31m
```

```
ingress                                    4.11.0    True        False         False      30m
insights                                   4.11.0    True        False         False      31m
kube-apiserver                             4.11.0    True        False         False      26m
kube-controller-manager                    4.11.0    True        False         False      36m
kube-scheduler                             4.11.0    True        False         False      36m
kube-storage-version-migrator              4.11.0    True        False         False      37m
machine-api                                4.11.0    True        False         False      29m
machine-approver                           4.11.0    True        False         False      37m
machine-config                             4.11.0    True        False         False      36m
marketplace                                4.11.0    True        False         False      37m
monitoring                                 4.11.0    True        False         False      29m
network                                    4.11.0    True        False         False      38m
node-tuning                                4.11.0    True        False         False      37m
openshift-apiserver                        4.11.0    True        False         False      32m
openshift-controller-manager               4.11.0    True        False         False      30m
openshift-samples                          4.11.0    True        False         False      32m
operator-lifecycle-manager                 4.11.0    True        False         False      37m
operator-lifecycle-manager-catalog         4.11.0    True        False         False      37m
operator-lifecycle-manager-packageserver   4.11.0    True        False         False      32m
service-ca                                 4.11.0    True        False         False      38m
storage                                    4.11.0    True        False         False      37m
```

Alternatively, the following command notifies you when all of the clusters are available. It also retrieves and displays credentials:

```
$ ./openshift-install --dir <installation_directory> wait-for install-complete 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

Example output

```
INFO Waiting up to 30m0s for the cluster to initialize...
```

The command succeeds when the Cluster Version Operator finishes deploying the OpenShift Container Platform cluster from Kubernetes API server.

IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.

- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

2. Confirm that the Kubernetes API server is communicating with the pods.

   a. To view a list of all pods, use the following command:

   ```
   $ oc get pods --all-namespaces
   ```

   Example output

   ```
   NAMESPACE                       NAME                                            READY   STATUS
   RESTARTS   AGE
   openshift-apiserver-operator    openshift-apiserver-operator-85cb746d55-zqhs8   1/1
   Running    1          9m
   openshift-apiserver             apiserver-67b9g                                 1/1     Running     0
   3m
   openshift-apiserver             apiserver-ljcmx                                 1/1     Running     0
   1m
   openshift-apiserver             apiserver-z25h4                                 1/1     Running     0
   2m
   openshift-authentication-operator authentication-operator-69d5d8bf84-vh2n8      1/1
   Running    0          5m
   ...
   ```

   b. View the logs for a pod that is listed in the output of the previous command by using the following command:

   ```
   $ oc logs <pod_name> -n <namespace> 1
   ```

   1 Specify the pod name and namespace, as shown in the output of the previous command.

   If the pod logs display, the Kubernetes API server can communicate with the cluster machines.

3. For an installation with Fibre Channel Protocol (FCP), additional steps are required to enable multipathing. Do not enable multipathing during installation.
   See "Enabling multipathing with kernel arguments on RHCOS" in the *Post-installation machine configuration tasks* documentation for more information.

4. Register your cluster on the Cluster registration page.

Additional resources

- How to generate SOSREPORT within OpenShift Container Platform version 4 nodes without SSH.

17.3.17. Next steps

- Customize your cluster.
- If the mirror registry that you used to install your cluster has a trusted CA, add it to the cluster by configuring additional trust stores.
- If necessary, you can opt out of remote health reporting .

- If necessary, see Registering your disconnected cluster

CHAPTER 18. INSTALLING ON IBM POWER

18.1. PREPARING TO INSTALL ON IBM POWER

18.1.1. Prerequisites

- You reviewed details about the OpenShift Container Platform installation and update processes.
- You read the documentation on selecting a cluster installation method and preparing it for users.

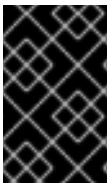
18.1.2. Choosing a method to install OpenShift Container Platform on IBM Power

You can install a cluster on IBM Power infrastructure that you provision, by using one of the following methods:

- **Installing a cluster on IBM Power**: You can install OpenShift Container Platform on IBM Power infrastructure that you provision.
- **Installing a cluster on IBM Power in a restricted network**: You can install OpenShift Container Platform on IBM Power infrastructure that you provision in a restricted or disconnected network, by using an internal mirror of the installation release content. You can use this method to install a cluster that does not require an active internet connection to obtain the software components. You can also use this installation method to ensure that your clusters only use container images that satisfy your organizational controls on external content.

18.2. INSTALLING A CLUSTER ON IBM POWER

In OpenShift Container Platform version 4.11, you can install a cluster on IBM Power infrastructure that you provision.



IMPORTANT

Additional considerations exist for non-bare metal platforms. Review the information in the guidelines for deploying OpenShift Container Platform on non-tested platforms before you install an OpenShift Container Platform cluster.

18.2.1. Prerequisites

- You reviewed details about the OpenShift Container Platform installation and update processes.
- You read the documentation on selecting a cluster installation method and preparing it for users.
- Before you begin the installation process, you must clean the installation directory. This ensures that the required installation files are created and updated during the installation process.
- You provisioned persistent storage using OpenShift Data Foundation or other supported storage protocols for your cluster. To deploy a private image registry, you must set up persistent storage with **ReadWriteMany** access.

- If you use a firewall, you configured it to allow the sites that your cluster requires access to.

NOTE

Be sure to also review this site list if you are configuring a proxy.

18.2.2. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.11, you require access to the internet to install your cluster.

You must have internet access to:

- Access OpenShift Cluster Manager Hybrid Cloud Console to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access Quay.io to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.

IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

18.2.3. Requirements for a cluster with user-provisioned infrastructure

For a cluster that contains user-provisioned infrastructure, you must deploy all of the required machines.

This section describes the requirements for deploying OpenShift Container Platform on user-provisioned infrastructure.

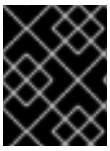
18.2.3.1. Required machines for cluster installation

The smallest OpenShift Container Platform clusters require the following hosts:

Table 18.1. Minimum required hosts

Hosts	Description
One temporary bootstrap machine	The cluster requires the bootstrap machine to deploy the OpenShift Container Platform cluster on the three control plane machines. You can remove the bootstrap machine after you install the cluster.
Three control plane machines	The control plane machines run the Kubernetes and OpenShift Container Platform services that form the control plane.

Hosts	Description
At least two compute machines, which are also known as worker machines.	The workloads requested by OpenShift Container Platform users run on the compute machines.



IMPORTANT

To maintain high availability of your cluster, use separate physical hosts for these cluster machines.

The bootstrap, control plane, and compute machines must use Red Hat Enterprise Linux CoreOS (RHCOS) as the operating system.

Note that RHCOS is based on Red Hat Enterprise Linux (RHEL) 8 and inherits all of its hardware certifications and requirements. See Red Hat Enterprise Linux technology capabilities and limits .

18.2.3.2. Minimum resource requirements for cluster installation

Each cluster machine must meet the following minimum requirements:

Table 18.2. Minimum resource requirements

Machine	Operating System	vCPU [1]	Virtual RAM	Storage	IOPS [2]
Bootstrap	RHCOS	2	16 GB	100 GB	300
Control plane	RHCOS	2	16 GB	100 GB	300
Compute	RHCOS	2	8 GB	100 GB	300

1. One vCPU is equivalent to one physical core when simultaneous multithreading (SMT), or hyperthreading, is not enabled. When enabled, use the following formula to calculate the corresponding ratio: (threads per core × cores) × sockets = vCPUs.
2. OpenShift Container Platform and Kubernetes are sensitive to disk performance, and faster storage is recommended, particularly for etcd on the control plane nodes. Note that on many cloud platforms, storage size and IOPS scale together, so you might need to over-allocate storage volume to obtain sufficient performance.

If an instance type for your platform meets the minimum requirements for cluster machines, it is supported to use in OpenShift Container Platform.

Additional resources

- Optimizing storage

18.2.3.3. Minimum IBM Power requirements

You can install OpenShift Container Platform version 4.11 on the following IBM hardware:

- IBM Power8, Power9, or Power10 processor-based systems

Hardware requirements

- Six IBM Power bare metal servers or six LPARs across multiple PowerVM servers

Operating system requirements

- One instance of an IBM Power8, Power9, or Power10 processor-based system

On your IBM Power instance, set up:

- Three guest virtual machines for OpenShift Container Platform control plane machines
- Two guest virtual machines for OpenShift Container Platform compute machines
- One guest virtual machine for the temporary OpenShift Container Platform bootstrap machine

Disk storage for the IBM Power guest virtual machines

- Local storage, or storage provisioned by the Virtual I/O Server using vSCSI, NPIV (N-Port ID Virtualization) or SSP (shared storage pools)

Network for the PowerVM guest virtual machines

- Dedicated physical adapter, or SR-IOV virtual function
- Available by the Virtual I/O Server using Shared Ethernet Adapter
- Virtualized by the Virtual I/O Server using IBM vNIC

Storage / main memory

- 100 GB / 16 GB for OpenShift Container Platform control plane machines
- 100 GB / 8 GB for OpenShift Container Platform compute machines
- 100 GB / 16 GB for the temporary OpenShift Container Platform bootstrap machine

18.2.3.4. Recommended IBM Power system requirements

Hardware requirements

- Six IBM Power bare metal servers or six LPARs across multiple PowerVM servers

Operating system requirements

- One instance of an IBM Power8, Power9, or Power10 processor-based system

On your IBM Power instance, set up:

- Three guest virtual machines for OpenShift Container Platform control plane machines
- Two guest virtual machines for OpenShift Container Platform compute machines
- One guest virtual machine for the temporary OpenShift Container Platform bootstrap machine

Disk storage for the IBM Power guest virtual machines

- Local storage, or storage provisioned by the Virtual I/O Server using vSCSI, NPIV (N-Port ID Virtualization) or SSP (shared storage pools)

Network for the PowerVM guest virtual machines

- Dedicated physical adapter, or SR-IOV virtual function
- Available by the Virtual I/O Server using Shared Ethernet Adapter
- Virtualized by the Virtual I/O Server using IBM vNIC

Storage / main memory

- 120 GB / 32 GB for OpenShift Container Platform control plane machines
- 120 GB / 32 GB for OpenShift Container Platform compute machines
- 120 GB / 16 GB for the temporary OpenShift Container Platform bootstrap machine

18.2.3.5. Certificate signing requests management

Because your cluster has limited access to automatic machine management when you use infrastructure that you provision, you must provide a mechanism for approving cluster certificate signing requests (CSRs) after installation. The **kube-controller-manager** only approves the kubelet client CSRs. The **machine-approver** cannot guarantee the validity of a serving certificate that is requested by using kubelet credentials because it cannot confirm that the correct machine issued the request. You must determine and implement a method of verifying the validity of the kubelet serving certificate requests and approving them.

18.2.3.6. Networking requirements for user-provisioned infrastructure

All the Red Hat Enterprise Linux CoreOS (RHCOS) machines require networking to be configured in **initramfs** during boot to fetch their Ignition config files.

During the initial boot, the machines require an IP address configuration that is set either through a DHCP server or statically by providing the required boot options. After a network connection is established, the machines download their Ignition config files from an HTTP or HTTPS server. The Ignition config files are then used to set the exact state of each machine. The Machine Config Operator completes more changes to the machines, such as the application of new certificates or keys, after installation.

It is recommended to use a DHCP server for long-term management of the cluster machines. Ensure that the DHCP server is configured to provide persistent IP addresses, DNS server information, and hostnames to the cluster machines.

NOTE

If a DHCP service is not available for your user-provisioned infrastructure, you can instead provide the IP networking configuration and the address of the DNS server to the nodes at RHCOS install time. These can be passed as boot arguments if you are installing from an ISO image. See the *Installing RHCOS and starting the OpenShift Container Platform bootstrap process* section for more information about static IP provisioning and advanced networking options.

The Kubernetes API server must be able to resolve the node names of the cluster machines. If the API servers and worker nodes are in different zones, you can configure a default DNS search zone to allow

the API server to resolve the node names. Another supported approach is to always refer to hosts by their fully-qualified domain names in both the node objects and all DNS requests.

18.2.3.6.1. Setting the cluster node hostnames through DHCP

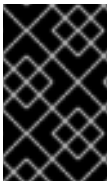
On Red Hat Enterprise Linux CoreOS (RHCOS) machines, the hostname is set through NetworkManager. By default, the machines obtain their hostname through DHCP. If the hostname is not provided by DHCP, set statically through kernel arguments, or another method, it is obtained through a reverse DNS lookup. Reverse DNS lookup occurs after the network has been initialized on a node and can take time to resolve. Other system services can start prior to this and detect the hostname as **localhost** or similar. You can avoid this by using DHCP to provide the hostname for each cluster node.

Additionally, setting the hostnames through DHCP can bypass any manual DNS record name configuration errors in environments that have a DNS split-horizon implementation.

18.2.3.6.2. Network connectivity requirements

You must configure the network connectivity between machines to allow OpenShift Container Platform cluster components to communicate. Each machine must be able to resolve the hostnames of all other machines in the cluster.

This section provides details about the ports that are required.



IMPORTANT

In connected OpenShift Container Platform environments, all nodes are required to have internet access to pull images for platform containers and provide telemetry data to Red Hat.

Table 18.3. Ports used for all-machine to all-machine communications

Protocol	Port	Description
ICMP	N/A	Network reachability tests
TCP	**1936**	Metrics
	9000-**9999**	Host level services, including the node exporter on ports **9100**-**9101** and the Cluster Version Operator on port**9099**.
	10250-**10259**	The default ports that Kubernetes reserves
	10256	openshift-sdn
UDP	**4789**	VXLAN
	6081	Geneve
	9000-**9999**	Host level services, including the node exporter on ports **9100**-**9101**.

Protocol	Port	Description
	500	IPsec IKE packets
	4500	IPsec NAT-T packets
TCP/UDP	**30000-32767**	Kubernetes node port
ESP	N/A	IPsec Encapsulating Security Payload (ESP)

Table 18.4. Ports used for all-machine to control plane communications

Protocol	Port	Description
TCP	**6443**	Kubernetes API

Table 18.5. Ports used for control plane machine to control plane machine communications

Protocol	Port	Description
TCP	**2379-2380**	etcd server and peer ports

NTP configuration for user-provisioned infrastructure
OpenShift Container Platform clusters are configured to use a public Network Time Protocol (NTP) server by default. If you want to use a local enterprise NTP server, or if your cluster is being deployed in a disconnected network, you can configure the cluster to use a specific time server. For more information, see the documentation for *Configuring chrony time service* .

If a DHCP server provides NTP server information, the chrony time service on the Red Hat Enterprise Linux CoreOS (RHCOS) machines read the information and can sync the clock with the NTP servers.

Additional resources

- Configuring chrony time service

18.2.3.7. User-provisioned DNS requirements

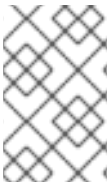
In OpenShift Container Platform deployments, DNS name resolution is required for the following components:

- The Kubernetes API
- The OpenShift Container Platform application wildcard
- The bootstrap, control plane, and compute machines

Reverse DNS resolution is also required for the Kubernetes API, the bootstrap machine, the control plane machines, and the compute machines.

DNS A/AAAA or CNAME records are used for name resolution and PTR records are used for reverse

name resolution. The reverse records are important because Red Hat Enterprise Linux CoreOS (RHCOS) uses the reverse records to set the hostnames for all the nodes, unless the hostnames are provided by DHCP. Additionally, the reverse records are used to generate the certificate signing requests (CSR) that OpenShift Container Platform needs to operate.



NOTE

It is recommended to use a DHCP server to provide the hostnames to each cluster node. See the *DHCP recommendations for user-provisioned infrastructure* section for more information.

The following DNS records are required for a user-provisioned OpenShift Container Platform cluster and they must be in place before installation. In each record, **<cluster_name>** is the cluster name and **<base_domain>** is the base domain that you specify in the **install-config.yaml** file. A complete DNS record takes the form: **<component>.<cluster_name>.<base_domain>.**.

Table 18.6. Required DNS records

Component	Record	Description
Kubernetes API	**api.<cluster_name>.<base_domain>.**	A DNS A/AAAA or CNAME record, and a DNS PTR record, to identify the API load balancer. These records must be resolvable by both clients external to the cluster and from all the nodes within the cluster.
	api-int.<cluster_name>.<base_domain>.	A DNS A/AAAA or CNAME record, and a DNS PTR record, to internally identify the API load balancer. These records must be resolvable from all the nodes within the cluster.  IMPORTANT The API server must be able to resolve the worker nodes by the hostnames that are recorded in Kubernetes. If the API server cannot resolve the node names, then proxied API calls can fail, and you cannot retrieve logs from pods.
Routes	***.apps.<cluster_name>.<base_domain>.**	A wildcard DNS A/AAAA or CNAME record that refers to the application ingress load balancer. The application ingress load balancer targets the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default. These records must be resolvable by both clients external to the cluster and from all the nodes within the cluster. For example, **console-openshift-console.apps.<cluster_name>.<base_domain>** is used as a wildcard route to the OpenShift Container Platform console.

Component	Record	Description
Bootstrap machine	**bootstrap.<cluster_name>.<base_domain>.**	A DNS A/AAAA or CNAME record, and a DNS PTR record, to identify the bootstrap machine. These records must be resolvable by the nodes within the cluster.
Control plane machines	**<master><n>.<cluster_name>.<base_domain>.**	DNS A/AAAA or CNAME records and DNS PTR records to identify each machine for the control plane nodes. These records must be resolvable by the nodes within the cluster.
Compute machines	**<worker><n>.<cluster_name>.<base_domain>.**	DNS A/AAAA or CNAME records and DNS PTR records to identify each machine for the worker nodes. These records must be resolvable by the nodes within the cluster.

NOTE

In OpenShift Container Platform 4.4 and later, you do not need to specify etcd host and SRV records in your DNS configuration.

TIP

You can use the **dig** command to verify name and reverse name resolution. See the section on *Validating DNS resolution for user-provisioned infrastructure* for detailed validation steps.

18.2.3.7.1. Example DNS configuration for user-provisioned clusters

This section provides A and PTR record configuration samples that meet the DNS requirements for deploying OpenShift Container Platform on user-provisioned infrastructure. The samples are not meant to provide advice for choosing one DNS solution over another.

In the examples, the cluster name is **ocp4** and the base domain is **example.com**.

Example DNS A record configuration for a user-provisioned cluster

The following example is a BIND zone file that shows sample A records for name resolution in a user-provisioned cluster.

Example 18.1. Sample DNS zone database

```
$TTL 1W
@ IN SOA ns1.example.com. root (
  2019070700 ; serial
  3H  ; refresh (3 hours)
  30M  ; retry (30 minutes)
  2W  ; expiry (2 weeks)
  1W )  ; minimum (1 week)
 IN NS ns1.example.com.
 IN MX 10 smtp.example.com.
;
;
```

```
ns1.example.com.  IN A 192.168.1.5
smtp.example.com.  IN A 192.168.1.5
;
helper.example.com.  IN A 192.168.1.5
helper.ocp4.example.com. IN A 192.168.1.5
;
api.ocp4.example.com.  IN A 192.168.1.5 1
api-int.ocp4.example.com. IN A 192.168.1.5 2
;
*.apps.ocp4.example.com. IN A 192.168.1.5 3
;
bootstrap.ocp4.example.com. IN A 192.168.1.96 4
;
master0.ocp4.example.com. IN A 192.168.1.97 5
master1.ocp4.example.com. IN A 192.168.1.98 6
master2.ocp4.example.com. IN A 192.168.1.99 7
;
worker0.ocp4.example.com. IN A 192.168.1.11 8
worker1.ocp4.example.com. IN A 192.168.1.7 9
;
;EOF
```

1 Provides name resolution for the Kubernetes API. The record refers to the IP address of the API load balancer.

2 Provides name resolution for the Kubernetes API. The record refers to the IP address of the API load balancer and is used for internal cluster communications.

3 Provides name resolution for the wildcard routes. The record refers to the IP address of the application ingress load balancer. The application ingress load balancer targets the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.

NOTE

In the example, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

4 Provides name resolution for the bootstrap machine.

5 6 7 Provides name resolution for the control plane machines.

8 9 Provides name resolution for the compute machines.

Example DNS PTR record configuration for a user-provisioned cluster

The following example BIND zone file shows sample PTR records for reverse name resolution in a user-provisioned cluster.

Example 18.2. Sample DNS zone database for reverse records

```
$TTL 1W
@ IN SOA ns1.example.com. root (
  2019070700 ; serial
  3H  ; refresh (3 hours)
  30M  ; retry (30 minutes)
  2W  ; expiry (2 weeks)
  1W )  ; minimum (1 week)
 IN NS ns1.example.com.
;
5.1.168.192.in-addr.arpa. IN PTR api.ocp4.example.com. 1
5.1.168.192.in-addr.arpa. IN PTR api-int.ocp4.example.com. 2
;
96.1.168.192.in-addr.arpa. IN PTR bootstrap.ocp4.example.com. 3
;
97.1.168.192.in-addr.arpa. IN PTR master0.ocp4.example.com. 4
98.1.168.192.in-addr.arpa. IN PTR master1.ocp4.example.com. 5
99.1.168.192.in-addr.arpa. IN PTR master2.ocp4.example.com. 6
;
11.1.168.192.in-addr.arpa. IN PTR worker0.ocp4.example.com. 7
7.1.168.192.in-addr.arpa. IN PTR worker1.ocp4.example.com. 8
;
;EOF
```

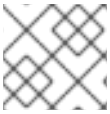
1 Provides reverse DNS resolution for the Kubernetes API. The PTR record refers to the record name of the API load balancer.

2 Provides reverse DNS resolution for the Kubernetes API. The PTR record refers to the record name of the API load balancer and is used for internal cluster communications.

3 Provides reverse DNS resolution for the bootstrap machine.

4 5 6 Provides reverse DNS resolution for the control plane machines.

7 8 Provides reverse DNS resolution for the compute machines.



NOTE

A PTR record is not required for the OpenShift Container Platform application wildcard.

18.2.3.8. Load balancing requirements for user-provisioned infrastructure

Before you install OpenShift Container Platform, you must provision the API and application ingress load balancing infrastructure. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

NOTE

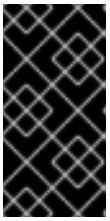
If you want to deploy the API and application Ingress load balancers with a Red Hat Enterprise Linux (RHEL) instance, you must purchase the RHEL subscription separately.

The load balancing infrastructure must meet the following requirements:

1. **API load balancer**: Provides a common endpoint for users, both human and machine, to interact with and configure the platform. Configure the following conditions:

   - Layer 4 load balancing only. This can be referred to as Raw TCP, SSL Passthrough, or SSL Bridge mode. If you use SSL Bridge mode, you must enable Server Name Indication (SNI) for the API routes.

   - A stateless load balancing algorithm. The options vary based on the load balancer implementation.



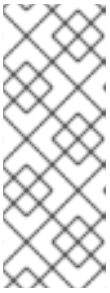
IMPORTANT

Do not configure session persistence for an API load balancer. Configuring session persistence for a Kubernetes API server might cause performance issues from excess application traffic for your OpenShift Container Platform cluster and the Kubernetes API that runs inside the cluster.

Configure the following ports on both the front and back of the load balancers:

Table 18.7. API load balancer

Port	Back-end machines (pool members)	Internal	External	Description
6443	Bootstrap and control plane. You remove the bootstrap machine from the load balancer after the bootstrap machine initializes the cluster control plane. You must configure the **/readyz** endpoint for the API server health check probe.	X	X	Kubernetes API server
22623	Bootstrap and control plane. You remove the bootstrap machine from the load balancer after the bootstrap machine initializes the cluster control plane.	X		Machine config server



NOTE

The load balancer must be configured to take a maximum of 30 seconds from the time the API server turns off the **/readyz** endpoint to the removal of the API server instance from the pool. Within the time frame after **/readyz** returns an error or becomes healthy, the endpoint must have been removed or added. Probing every 5 or 10 seconds, with two successful requests to become healthy and three to become unhealthy, are well-tested values.

2. **Application Ingress load balancer**: Provides an ingress point for application traffic flowing in from outside the cluster. A working configuration for the Ingress router is required for an OpenShift Container Platform cluster.
Configure the following conditions:

- Layer 4 load balancing only. This can be referred to as Raw TCP, SSL Passthrough, or SSL Bridge mode. If you use SSL Bridge mode, you must enable Server Name Indication (SNI) for the ingress routes.
- A connection-based or session-based persistence is recommended, based on the options available and types of applications that will be hosted on the platform.

TIP

If the true IP address of the client can be seen by the application Ingress load balancer, enabling source IP-based session persistence can improve performance for applications that use end-to-end TLS encryption.

Configure the following ports on both the front and back of the load balancers:

Table 18.8. Application Ingress load balancer

Port	Back-end machines (pool members)	Internal	External	Description
443	The machines that run the Ingress Controller pods, compute, or worker, by default.	X	X	HTTPS traffic
80	The machines that run the Ingress Controller pods, compute, or worker, by default.	X	X	HTTP traffic

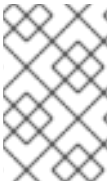
NOTE

If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application Ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes.

18.2.3.8.1. Example load balancer configuration for user-provisioned clusters

This section provides an example API and application ingress load balancer configuration that meets the load balancing requirements for user-provisioned clusters. The sample is an **/etc/haproxy/haproxy.cfg** configuration for an HAProxy load balancer. The example is not meant to provide advice for choosing one load balancing solution over another.

In the example, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.



NOTE

If you are using HAProxy as a load balancer and SELinux is set to **enforcing**, you must ensure that the HAProxy service can bind to the configured TCP port by running **setsebool -P haproxy_connect_any=1**.

Example 18.3. Sample API and application Ingress load balancer configuration

```
global
  log         127.0.0.1 local2
  pidfile     /var/run/haproxy.pid
  maxconn     4000
  daemon
defaults
  mode                    http
  log                     global
  option                  dontlognull
  option http-server-close
  option                  redispatch
  retries                 3
  timeout http-request    10s
  timeout queue           1m
  timeout connect         10s
  timeout client          1m
  timeout server          1m
  timeout http-keep-alive 10s
  timeout check           10s
  maxconn                 3000
listen api-server-6443 (1)
  bind *:6443
  mode tcp
  server bootstrap bootstrap.ocp4.example.com:6443 check inter 1s backup (2)
  server master0 master0.ocp4.example.com:6443 check inter 1s
  server master1 master1.ocp4.example.com:6443 check inter 1s
  server master2 master2.ocp4.example.com:6443 check inter 1s
listen machine-config-server-22623 (3)
  bind *:22623
  mode tcp
  option  httpchk GET /readyz HTTP/1.0
  option  log-health-checks
  balance roundrobin
  server bootstrap bootstrap.ocp4.example.com:6443 verify none check check-ssl inter 10s fall 2
rise 3 backup (4)
  server master0 master0.ocp4.example.com:6443 weight 1 verify none check check-ssl inter 10s
fall 2 rise 3
  server master1 master1.ocp4.example.com:6443 weight 1 verify none check check-ssl inter 10s
fall 2 rise 3
  server master2 master2.ocp4.example.com:6443 weight 1 verify none check check-ssl inter 10s
fall 2 rise 3
listen ingress-router-443 (5)
  bind *:443
  mode tcp
  balance source
  server worker0 worker0.ocp4.example.com:443 check inter 1s
  server worker1 worker1.ocp4.example.com:443 check inter 1s
listen ingress-router-80 (6)
  bind *:80
  mode tcp
  balance source
  server worker0 worker0.ocp4.example.com:80 check inter 1s
  server worker1 worker1.ocp4.example.com:80 check inter 1s
```

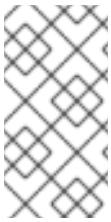
(1) Port **6443** handles the Kubernetes API traffic and points to the control plane machines.

2 4 The bootstrap entries must be in place before the OpenShift Container Platform cluster installation and they must be removed after the bootstrap process is complete.

3 Port **22623** handles the machine config server traffic and points to the control plane machines.

5 Port **443** handles the HTTPS traffic and points to the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.

6 Port **80** handles the HTTP traffic and points to the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.



NOTE

If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application Ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes.

TIP

If you are using HAProxy as a load balancer, you can check that the **haproxy** process is listening on ports **6443**, **22623**, **443**, and **80** by running **netstat -nltupe** on the HAProxy node.

18.2.4. Preparing the user-provisioned infrastructure

Before you install OpenShift Container Platform on user-provisioned infrastructure, you must prepare the underlying infrastructure.

This section provides details about the high-level steps required to set up your cluster infrastructure in preparation for an OpenShift Container Platform installation. This includes configuring IP networking and network connectivity for your cluster nodes, enabling the required ports through your firewall, and setting up the required DNS and load balancing infrastructure.

After preparation, your cluster infrastructure must meet the requirements outlined in the *Requirements for a cluster with user-provisioned infrastructure* section.

Prerequisites

- You have reviewed the OpenShift Container Platform 4.x Tested Integrations page.
- You have reviewed the infrastructure requirements detailed in the *Requirements for a cluster with user-provisioned infrastructure* section.

Procedure

1. If you are using DHCP to provide the IP networking configuration to your cluster nodes, configure your DHCP service.
    a. Add persistent IP addresses for the nodes to your DHCP server configuration. In your configuration, match the MAC address of the relevant network interface to the intended IP address for each node.

b. When you use DHCP to configure IP addressing for the cluster machines, the machines also obtain the DNS server information through DHCP. Define the persistent DNS server address that is used by the cluster nodes through your DHCP server configuration.

NOTE

If you are not using a DHCP service, you must provide the IP networking configuration and the address of the DNS server to the nodes at RHCOS install time. These can be passed as boot arguments if you are installing from an ISO image. See the *Installing RHCOS and starting the OpenShift Container Platform bootstrap process* section for more information about static IP provisioning and advanced networking options.

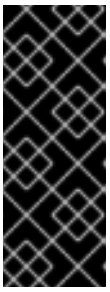
c. Define the hostnames of your cluster nodes in your DHCP server configuration. See the *Setting the cluster node hostnames through DHCP* section for details about hostname considerations.

NOTE

If you are not using a DHCP service, the cluster nodes obtain their hostname through a reverse DNS lookup.

2. Ensure that your network infrastructure provides the required network connectivity between the cluster components. See the *Networking requirements for user-provisioned infrastructure* section for details about the requirements.

3. Configure your firewall to enable the ports required for the OpenShift Container Platform cluster components to communicate. See *Networking requirements for user-provisioned infrastructure* section for details about the ports that are required.



IMPORTANT

By default, port **1936** is accessible for an OpenShift Container Platform cluster, because each control plane node needs access to this port.

Avoid using the Ingress load balancer to expose this port, because doing so might result in the exposure of sensitive information, such as statistics and metrics, related to Ingress Controllers.

4. Setup the required DNS infrastructure for your cluster.

   a. Configure DNS name resolution for the Kubernetes API, the application wildcard, the bootstrap machine, the control plane machines, and the compute machines.

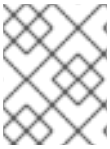
   b. Configure reverse DNS resolution for the Kubernetes API, the bootstrap machine, the control plane machines, and the compute machines.
   See the *User-provisioned DNS requirements* section for more information about the OpenShift Container Platform DNS requirements.

5. Validate your DNS configuration.

   a. From your installation node, run DNS lookups against the record names of the Kubernetes API, the wildcard routes, and the cluster nodes. Validate that the IP addresses in the responses correspond to the correct components.

b. From your installation node, run reverse DNS lookups against the IP addresses of the load balancer and the cluster nodes. Validate that the record names in the responses correspond to the correct components.
See the *Validating DNS resolution for user-provisioned infrastructure* section for detailed DNS validation steps.

6. Provision the required API and application ingress load balancing infrastructure. See the *Load balancing requirements for user-provisioned infrastructure* section for more information about the requirements.



NOTE

Some load balancing solutions require the DNS name resolution for the cluster nodes to be in place before the load balancing is initialized.

18.2.5. Validating DNS resolution for user-provisioned infrastructure

You can validate your DNS configuration before installing OpenShift Container Platform on user-provisioned infrastructure.

IMPORTANT

The validation steps detailed in this section must succeed before you install your cluster.

Prerequisites

- You have configured the required DNS records for your user-provisioned infrastructure.

Procedure

1. From your installation node, run DNS lookups against the record names of the Kubernetes API, the wildcard routes, and the cluster nodes. Validate that the IP addresses contained in the responses correspond to the correct components.

   a. Perform a lookup against the Kubernetes API record name. Check that the result points to the IP address of the API load balancer:

   ```
   $ dig +noall +answer @<nameserver_ip> api.<cluster_name>.<base_domain>
   ```
   (1)

   (1) Replace **<nameserver_ip>** with the IP address of the nameserver, **<cluster_name>** with your cluster name, and **<base_domain>** with your base domain name.

   Example output

   ```
   api.ocp4.example.com.  604800 IN A 192.168.1.5
   ```

   b. Perform a lookup against the Kubernetes internal API record name. Check that the result points to the IP address of the API load balancer:

   ```
   $ dig +noall +answer @<nameserver_ip> api-int.<cluster_name>.<base_domain>
   ```

   Example output

```
api-int.ocp4.example.com.  604800 IN A 192.168.1.5
```

c. Test an example ***.apps.<cluster_name>.<base_domain>** DNS wildcard lookup. All of the application wildcard lookups must resolve to the IP address of the application ingress load balancer:

```
$ dig +noall +answer @<nameserver_ip> random.apps.<cluster_name>.<base_domain>
```

Example output

```
random.apps.ocp4.example.com.  604800 IN A 192.168.1.5
```

NOTE

In the example outputs, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

You can replace **random** with another wildcard value. For example, you can query the route to the OpenShift Container Platform console:

```
$ dig +noall +answer @<nameserver_ip> console-openshift-console.apps.
<cluster_name>.<base_domain>
```

Example output

```
console-openshift-console.apps.ocp4.example.com. 604800 IN A 192.168.1.5
```

d. Run a lookup against the bootstrap DNS record name. Check that the result points to the IP address of the bootstrap node:

```
$ dig +noall +answer @<nameserver_ip> bootstrap.<cluster_name>.<base_domain>
```

Example output

```
bootstrap.ocp4.example.com.  604800 IN A 192.168.1.96
```

e. Use this method to perform lookups against the DNS record names for the control plane and compute nodes. Check that the results correspond to the IP addresses of each node.

2. From your installation node, run reverse DNS lookups against the IP addresses of the load balancer and the cluster nodes. Validate that the record names contained in the responses correspond to the correct components.

a. Perform a reverse lookup against the IP address of the API load balancer. Check that the response includes the record names for the Kubernetes API and the Kubernetes internal API:

```
$ dig +noall +answer @<nameserver_ip> -x 192.168.1.5
```

Example output

```
5.1.168.192.in-addr.arpa. 604800 IN PTR api-int.ocp4.example.com. 1
5.1.168.192.in-addr.arpa. 604800 IN PTR api.ocp4.example.com. 2
```

1 Provides the record name for the Kubernetes internal API.

2 Provides the record name for the Kubernetes API.

NOTE

A PTR record is not required for the OpenShift Container Platform application wildcard. No validation step is needed for reverse DNS resolution against the IP address of the application ingress load balancer.

b. Perform a reverse lookup against the IP address of the bootstrap node. Check that the result points to the DNS record name of the bootstrap node:

```
$ dig +noall +answer @<nameserver_ip> -x 192.168.1.96
```

Example output

```
96.1.168.192.in-addr.arpa. 604800 IN PTR bootstrap.ocp4.example.com.
```

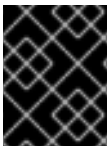
c. Use this method to perform reverse lookups against the IP addresses for the control plane and compute nodes. Check that the results correspond to the DNS record names of each node.

18.2.6. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the ~/**.ssh/authorized_keys** list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The **./openshift-install gather** command also requires the SSH public key to be in place on the cluster nodes.



IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.

NOTE

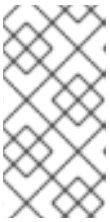
You must use a local key, not one that you configured with platform-specific approaches such as AWS key pairs.

Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N '' -f <path>/<file_name> 1
```

1 Specify the path and file name, such as ~/**.ssh/id_ed25519**, of the new SSH key. If you have an existing key pair, ensure your public key is in the your ~/**.ssh** directory.



NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS validated or Modules In Process cryptographic libraries on the **x86_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

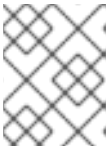
2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the ~/**.ssh/id_ed25519.pub** public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the **./openshift-install gather** command.



NOTE

On some distributions, default SSH private key identities such as ~/**.ssh/id_rsa** and ~/**.ssh/id_dsa** are managed automatically.

a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

Example output

```
Agent pid 31874
```

NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

1 Specify the path and file name for your SSH private key, such as **~/.ssh/id_ed25519**

Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

18.2.7. Obtaining the installation program

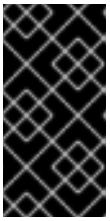
Before you install OpenShift Container Platform, download the installation file on a local computer.

Prerequisites

- You have a computer that runs Linux or macOS, with 500 MB of local disk space.

Procedure

1. Access the Infrastructure Provider page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program that corresponds with your host operating system and architecture, and place the file in the directory where you will store the installation configuration files.



IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.

IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation pull secret from the Red Hat OpenShift Cluster Manager . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

18.2.8. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.

IMPORTANT

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.11. Download and install the new version of **oc**.

Installing the OpenShift CLI on Linux

You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the architecture in the **Product Variant** drop-down menu.
3. Select the appropriate version in the **Version** drop-down menu.
4. Click **Download Now** next to the **OpenShift v4.11 Linux Client** entry and save the file.
5. Unpack the archive:

```
$ tar xvf <file>
```

6. Place the **oc** binary in a directory that is on your **PATH**.
   To check your **PATH**, execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.
   To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
C:\> oc <command>
```

Installing the OpenShift CLI on macOS
You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 macOS Client** entry and save the file.

NOTE

For macOS arm64, choose the **OpenShift v4.11 macOS arm64 Client** entry.

4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your PATH.
   To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

18.2.9. Manually creating the installation configuration file

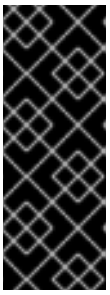
Prerequisites

- You have an SSH public key on your local machine to provide to the installation program. The key will be used for SSH authentication onto your cluster nodes for debugging and disaster recovery.
- You have obtained the OpenShift Container Platform installation program and the pull secret for your cluster.

Procedure

1. Create an installation directory to store your required installation assets in:

```
$ mkdir <installation_directory>
```



IMPORTANT

You must create a directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

2. Customize the sample **install-config.yaml** file template that is provided and save it in the **<installation_directory>**.

NOTE

You must name this configuration file **install-config.yaml**.

NOTE

For some platform types, you can alternatively run **./openshift-install create install-config --dir <installation_directory>** to generate an **install-config.yaml** file. You can provide details about your cluster configuration at the prompts.

3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.

IMPORTANT

The **install-config.yaml** file is consumed during the next step of the installation process. You must back it up now.

18.2.9.1. Installation configuration parameters

Before you deploy an OpenShift Container Platform cluster, you provide a customized **install-config.yaml** installation configuration file that describes the details for your environment.

NOTE

After installation, you cannot modify these parameters in the **install-config.yaml** file.

18.2.9.1.1. Required configuration parameters

Required installation configuration parameters are described in the following table:

Table 18.9. Required parameters

Parameter	Description	Values
apiVersion	The API version for the **install-config.yaml** content. The current version is **v1**. The installer may also support older API versions.	String
baseDomain	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the **baseDomain** and **metadata.name** parameter values that uses the **<metadata.name>.<baseDomain>** format.	A fully-qualified domain or subdomain name, such as **example.com**.
metadata	Kubernetes resource **ObjectMeta**, from which only the **name** parameter is consumed.	Object
metadata.name	The name of the cluster. DNS records for the cluster are all subdomains of **{{.metadata.name}}.{{.baseDomain}}**.	String of lowercase letters, hyphens (**-**), and periods (**.**), such as **dev**.
platform	The configuration for the specific platform upon which to perform the installation: **alibabacloud**, **aws**, **baremetal**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**. For additional information about **platform.<platform>** parameters, consult the table for your specific platform that follows.	Object

Parameter	Description	Values
pullSecret	Get a pull secret from the Red Hat OpenShift Cluster Manager to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	<pre>{ "auths":{ "cloud.openshift.com":{ "auth":"b3Blb=", "email":"you@example.com" }, "quay.io":{ "auth":"b3Blb=", "email":"you@example.com" } } }</pre>

18.2.9.1.2. Network configuration parameters

You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

- If you use the OVN-Kubernetes cluster network provider, both IPv4 and IPv6 address families are supported.
- If you use the OpenShift SDN cluster network provider, only the IPv4 address family is supported.

If you configure your cluster to use both IP address families, review the following requirements:

- Both IP families must use the same network interface for the default gateway.
- Both IP families must have the default gateway.
- You must specify IPv4 and IPv6 addresses in the same order for all network configuration parameters. For example, in the following configuration IPv4 addresses are listed before IPv6 addresses.

```
networking:
  clusterNetwork:
  - cidr: 10.128.0.0/14
    hostPrefix: 23
  - cidr: fd00:10:128::/56
    hostPrefix: 64
  serviceNetwork:
  - 172.30.0.0/16
  - fd00:172:16::/112
```

NOTE

Globalnet is not supported with Red Hat OpenShift Data Foundation disaster recovery solutions. For regional disaster recovery scenarios, ensure that you use a nonoverlapping range of private IP addresses for the cluster and service networks in each cluster.

Table 18.10. Network parameters

Parameter	Description	Values
networking	The configuration for the cluster network.	Object  **NOTE** You cannot modify parameters specified by the **networking** object after installation.
networking.networkType	The cluster network provider Container Network Interface (CNI) cluster network provider to install.	Either **OpenShiftSDN** or **OVNKubernetes**. **OpenShiftSDN** is a CNI provider for all-Linux networks. **OVNKubernetes** is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is **OpenShiftSDN**.
networking.clusterNetwork	The IP address blocks for pods. The default value is **10.128.0.0/14** with a host prefix of **/23**. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: `networking:` `  clusterNetwork:` `  - cidr: 10.128.0.0/14` `    hostPrefix: 23`
networking.clusterNetwork.cidr	Required if you use **networking.clusterNetwork**. An IP address block. An IPv4 network.	An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between **0** and **32**.
networking.clusterNetwork.hostPrefix	The subnet prefix length to assign to each individual node. For example, if **hostPrefix** is set to **23** then each node is assigned a **/23** subnet out of the given **cidr**. A **hostPrefix** value of **23** provides 510 (2^(32 - 23) - 2) pod IP addresses.	A subnet prefix. The default value is **23**.
networking.serviceNetwork	The IP address block for services. The default value is **172.30.0.0/16**. The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.	An array with an IP address block in CIDR format. For example: `networking:` `  serviceNetwork:` `  - 172.30.0.0/16`

Parameter	Description	Values
networking.machineNetwork	The IP address blocks for machines. If you specify multiple IP address blocks, the blocks must not overlap. If you specify multiple IP kernel arguments, the **machineNetwork.cidr** value must be the CIDR of the primary network.	An array of objects. For example: `networking:` `  machineNetwork:` `  - cidr: 10.0.0.0/16`
networking.machineNetwork.cidr	Required if you use **networking.machineNetwork**. An IP address block. The default value is **10.0.0.0/16** for all platforms other than libvirt. For libvirt, the default value is **192.168.126.0/24**.	An IP network block in CIDR notation. For example, **10.0.0.0/16**. **NOTE** Set the **networking.machineNetwork** to match the CIDR that the preferred NIC resides in.

18.2.9.1.3. Optional configuration parameters

Optional installation configuration parameters are described in the following table:

Table 18.11. Optional parameters

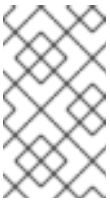
Parameter	Description	Values
additionalTrustBundle	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String
capabilities	Controls the installation of optional core cluster components. You can reduce the footprint of your OpenShift Container Platform cluster by disabling optional components.	String array

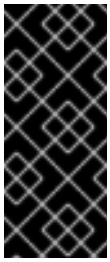
Parameter	Description	Values
capabilities.baselineCapabilitySet	Selects an initial set of optional capabilities to enable. Valid values are **None**, **v4.11** and **vCurrent**. **v4.11** enables the **baremetal** Operator, the **marketplace** Operator, and the **openshift-samples** content. **vCurrent** installs the recommended set of capabilities for the current version of OpenShift Container Platform. The default value is **vCurrent**.	String
capabilities.additionalEnabledCapabilities	Extends the set of optional capabilities beyond what you specify in **baselineCapabilitySet**. Valid values are **baremetal**, **marketplace** and **openshift-samples**. You may specify multiple capabilities in this parameter.	String array
cgroupsV2	Enables Linux control groups version 2 (cgroups v2) on specific nodes in your cluster. The OpenShift Container Platform process for enabling cgroups v2 disables all cgroup version 1 controllers and hierarchies. The OpenShift Container Platform cgroups version 2 feature is in Developer Preview and is not supported by Red Hat at this time.	**true**
compute	The configuration for the machines that comprise the compute nodes.	Array of **MachinePool** objects.
compute.architecture	Determines the instruction set architecture of the machines in the pool. Currently, heteregeneous clusters are not supported, so all pools must specify the same architecture. Valid values are **ppc64le** (the default).	String

Parameter	Description	Values
compute.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  IMPORTANT If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
compute.name	Required if you use **compute**. The name of the machine pool.	**worker**
compute.platform	Required if you use **compute**. Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the **controlPlane.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
compute.replicas	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to **2**. The default value is **3**.
controlPlane	The configuration for the machines that comprise the control plane.	Array of **MachinePool** objects.
controlPlane.architecture	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are **ppc64le** (the default).	String

Parameter	Description	Values
controlPlane.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  **IMPORTANT** If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
controlPlane.name	Required if you use **controlPlane**. The name of the machine pool.	**master**
controlPlane.platform	Required if you use **controlPlane**. Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the **compute.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
controlPlane.replicas	The number of control plane machines to provision.	The only supported value is **3**, which is the default value.

Parameter	Description	Values
credentialsMode	The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported.  **NOTE** Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the *Cloud Credential Operator* entry in the *Cluster Operators reference* content.  **NOTE** If your AWS account has service control policies (SCP) enabled, you must configure the **credentialsMode** parameter to **Mint**, **Passthrough** or **Manual**.	**Mint**, **Passthrough**, **Manual** or an empty string (**""**).
fips	Enable or disable FIPS mode. The default is **false** (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.	**false** or **true**

Parameter	Description	Values
	IMPORTANT  To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.  **NOTE** If you are using Azure File storage, you cannot enable FIPS mode.	
imageContentSources	Sources and repositories for the release-image content.	Array of objects. Includes a **source** and, optionally, **mirrors**, as described in the following rows of this table.
imageContentSources.source	Required if you use **imageContentSources**. Specify the repository that users refer to, for example, in image pull specifications.	String
imageContentSources.mirrors	Specify one or more repositories that may also contain the same images.	Array of strings

Parameter	Description	Values
publish	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	**Internal** or **External**. The default value is **External**. Setting this field to **Internal** is not supported on non-cloud platforms and IBM Cloud VPC.  **IMPORTANT** If the value of the field is set to **Internal**, the cluster will become non-functional. For more information, refer to BZ#1953035.
sshKey	The SSH key to authenticate access to your cluster machines.  **NOTE** For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.	For example, **sshKey: ssh-ed25519 AAAA..**.

18.2.9.2. Sample install-config.yaml file for IBM Power

You can customize the **install-config.yaml** file to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.

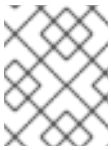
```
apiVersion: v1
baseDomain: example.com (1)
compute: (2)
- hyperthreading: Enabled (3)
```

```
  name: worker
  replicas: 0 4
  architecture : ppc64le
controlPlane: 5
  hyperthreading: Enabled 6
  name: master
  replicas: 3 7
  architecture : ppc64le
metadata:
  name: test 8
networking:
  clusterNetwork:
  - cidr: 10.128.0.0/14 9
    hostPrefix: 23 10
  networkType: OpenShiftSDN
  serviceNetwork: 11
  - 172.30.0.0/16
platform:
  none: {} 12
fips: false 13
pullSecret: '{"auths": ...}' 14
sshKey: 'ssh-ed25519 AAAA...' 15
```

1 The base domain of the cluster. All DNS records must be sub-domains of this base and include the cluster name.

2 5 The **controlPlane** section is a single mapping, but the **compute** section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, **-**, and the first line of the **controlPlane** section must not. Only one control plane pool is used.

3 6 Specifies whether to enable or disable simultaneous multithreading (SMT), or hyperthreading. By default, SMT is enabled to increase the performance of the cores in your machines. You can disable it by setting the parameter value to **Disabled**. If you disable SMT, you must disable it in all cluster machines; this includes both control plane and compute machines.



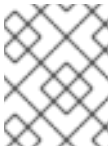
NOTE

Simultaneous multithreading (SMT) is enabled by default. If SMT is not enabled in your BIOS settings, the **hyperthreading** parameter has no effect.

IMPORTANT

If you disable **hyperthreading**, whether in the BIOS or in the **install-config.yaml** file, ensure that your capacity planning accounts for the dramatically decreased machine performance.

4 You must set this value to **0** when you install OpenShift Container Platform on user-provisioned infrastructure. In installer-provisioned installations, the parameter controls the number of compute machines that the cluster creates and manages for you. In user-provisioned installations, you must manually deploy the compute machines before you finish installing the cluster.



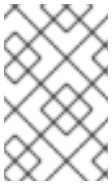
NOTE

If you are installing a three-node cluster, do not deploy any compute machines when you install the Red Hat Enterprise Linux CoreOS (RHCOS) machines.

7 The number of control plane machines that you add to the cluster. Because the cluster uses these values as the number of etcd endpoints in the cluster, the value must match the number of control plane machines that you deploy.

8 The cluster name that you specified in your DNS records.

9 A block of IP addresses from which pod IP addresses are allocated. This block must not overlap with existing physical networks. These IP addresses are used for the pod network. If you need to access the pods from an external network, you must configure load balancers and routers to manage the traffic.



NOTE

Class E CIDR range is reserved for a future use. To use the Class E CIDR range, you must ensure your networking environment accepts the IP addresses within the Class E CIDR range.

10 The subnet prefix length to assign to each individual node. For example, if **hostPrefix** is set to **23**, then each node is assigned a /**23** subnet out of the given **cidr**, which allows for 510 (2^(32 - 23) - 2) pod IP addresses. If you are required to provide access to nodes from an external network, configure load balancers and routers to manage the traffic.

11 The IP address pool to use for service IP addresses. You can enter only one IP address pool. This block must not overlap with existing physical networks. If you need to access the services from an external network, configure load balancers and routers to manage the traffic.

12 You must set the platform to **none**. You cannot provide additional platform configuration variables for IBM Power infrastructure.

IMPORTANT

Clusters that are installed with the platform type **none** are unable to use some features, such as managing compute machines with the Machine API. This limitation applies even if the compute machines that are attached to the cluster are installed on a platform that would normally support the feature. This parameter cannot be changed after installation.

13 Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.

IMPORTANT

To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.

14 The pull secret from the Red Hat OpenShift Cluster Manager . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

15 The SSH public key for the **core** user in Red Hat Enterprise Linux CoreOS (RHCOS).

NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

18.2.9.3. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.

NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

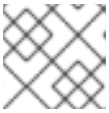
Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
```

```
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
```

1. A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
2. A proxy URL to use for creating HTTPS connections outside the cluster.
3. A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use * to bypass the proxy for all destinations.
4. If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace that contains one or more additional CA certificates that are required for proxying HTTPS connections. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges these contents with the Red Hat Enterprise Linux CoreOS (RHCOS) trust bundle, and this config map is referenced in the **trustedCA** field of the **Proxy** object. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.



NOTE

The installation program does not support the proxy **readinessEndpoints** field.

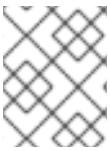
NOTE

If the installer times out, restart and then complete the deployment by using the **wait-for** command of the installer. For example:

```
$ ./openshift-install wait-for install-complete --log-level debug
```

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.



NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

18.2.9.4. Configuring a three-node cluster

Optionally, you can deploy zero compute machines in a bare metal cluster that consists of three control plane machines only. This provides smaller, more resource efficient clusters for cluster administrators and developers to use for testing, development, and production.

In three-node OpenShift Container Platform environments, the three control plane machines are schedulable, which means that your application workloads are scheduled to run on them.

Prerequisites

- You have an existing **install-config.yaml** file.

Procedure

- Ensure that the number of compute replicas is set to **0** in your **install-config.yaml** file, as shown in the following **compute** stanza:

```
compute:
- name: worker
  platform: {}
  replicas: 0
```

NOTE

You must set the value of the **replicas** parameter for the compute machines to **0** when you install OpenShift Container Platform on user-provisioned infrastructure, regardless of the number of compute machines you are deploying. In installer-provisioned installations, the parameter controls the number of compute machines that the cluster creates and manages for you. This does not apply to user-provisioned installations, where the compute machines are deployed manually.

For three-node cluster installations, follow these next steps:

- If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes. See the *Load balancing requirements for user-provisioned infrastructure* section for more information.

- When you create the Kubernetes manifest files in the following procedure, ensure that the **mastersSchedulable** parameter in the **<installation_directory>/manifests/cluster-scheduler-02-config.yml** file is set to **true**. This enables your application workloads to run on the control plane nodes.

- Do not deploy any compute nodes when you create the Red Hat Enterprise Linux CoreOS (RHCOS) machines.

18.2.10. Cluster Network Operator configuration

The configuration for the cluster network is specified as part of the Cluster Network Operator (CNO) configuration and stored in a custom resource (CR) object that is named **cluster**. The CR specifies the fields for the **Network** API in the **operator.openshift.io** API group.

The CNO configuration inherits the following fields during cluster installation from the **Network** API in the **Network.config.openshift.io** API group and these fields cannot be changed:

clusterNetwork

IP address pools from which pod IP addresses are allocated.

serviceNetwork

IP address pool for services.

defaultNetwork.type

Cluster network provider, such as OpenShift SDN or OVN-Kubernetes.

You can specify the cluster network provider configuration for your cluster by setting the fields for the **defaultNetwork** object in the CNO object named **cluster**.

18.2.10.1. Cluster Network Operator configuration object

The fields for the Cluster Network Operator (CNO) are described in the following table:

Table 18.12. Cluster Network Operator configuration object

Field	Type	Description
metadata.name	**string**	The name of the CNO object. This name is always **cluster**.
spec.clusterNetwork	**array**	A list specifying the blocks of IP addresses from which pod IP addresses are allocated and the subnet prefix length assigned to each individual node in the cluster. For example: `spec:` `  clusterNetwork:` `  - cidr: 10.128.0.0/19` `  hostPrefix: 23` `  - cidr: 10.128.32.0/19` `  hostPrefix: 23` You can customize this field only in the **install-config.yaml** file before you create the manifests. The value is read-only in the manifest file.
spec.serviceNetwork	**array**	A block of IP addresses for services. The OpenShift SDN and OVN-Kubernetes Container Network Interface (CNI) network providers support only a single IP address block for the service network. For example: `spec:` `  serviceNetwork:` `  - 172.30.0.0/14` You can customize this field only in the **install-config.yaml** file before you create the manifests. The value is read-only in the manifest file.
spec.defaultNetwork	**object**	Configures the Container Network Interface (CNI) cluster network provider for the cluster network.

Field	Type	Description
spec.kubeProxyConfig	**object**	The fields for this object specify the kube-proxy configuration. If you are using the OVN-Kubernetes cluster network provider, the kube-proxy configuration has no effect.

defaultNetwork object configuration

The values for the **defaultNetwork** object are defined in the following table:

Table 18.13. **defaultNetwork** object

Field	Type	Description
type	**string**	Either **OpenShiftSDN** or **OVNKubernetes**. The cluster network provider is selected during installation. This value cannot be changed after cluster installation.  **NOTE** OpenShift Container Platform uses the OpenShift SDN Container Network Interface (CNI) cluster network provider by default.
openshiftSDNConfig	**object**	This object is only valid for the OpenShift SDN cluster network provider.
ovnKubernetesConfig	**object**	This object is only valid for the OVN-Kubernetes cluster network provider.

Configuration for the OpenShift SDN CNI cluster network provider

The following table describes the configuration fields for the OpenShift SDN Container Network Interface (CNI) cluster network provider.

Table 18.14. **openshiftSDNConfig** object

Field	Type	Description
mode	**string**	Configures the network isolation mode for OpenShift SDN. The default value is **NetworkPolicy**. The values **Multitenant** and **Subnet** are available for backwards compatibility with OpenShift Container Platform 3.x but are not recommended. This value cannot be changed after cluster installation.

Field	Type	Description
mtu	**integer**	The maximum transmission unit (MTU) for the VXLAN overlay network. This is detected automatically based on the MTU of the primary network interface. You do not normally need to override the detected MTU. If the auto-detected value is not what you expect it to be, confirm that the MTU on the primary network interface on your nodes is correct. You cannot use this option to change the MTU value of the primary network interface on the nodes. If your cluster requires different MTU values for different nodes, you must set this value to **50** less than the lowest MTU value in your cluster. For example, if some nodes in your cluster have an MTU of **9001**, and some have an MTU of**1500**, you must set this value to **1450**. This value cannot be changed after cluster installation.
vxlanPort	**integer**	The port to use for all VXLAN packets. The default value is **4789**. This value cannot be changed after cluster installation. If you are running in a virtualized environment with existing nodes that are part of another VXLAN network, then you might be required to change this. For example, when running an OpenShift SDN overlay on top of VMware NSX-T, you must select an alternate port for the VXLAN, because both SDNs use the same default VXLAN port number. On Amazon Web Services (AWS), you can select an alternate port for the VXLAN between port **9000** and port **9999**.

Example OpenShift SDN configuration

```
defaultNetwork:
  type: OpenShiftSDN
  openshiftSDNConfig:
    mode: NetworkPolicy
    mtu: 1450
    vxlanPort: 4789
```

Configuration for the OVN-Kubernetes CNI cluster network provider

The following table describes the configuration fields for the OVN-Kubernetes CNI cluster network provider.

Table 18.15. ovnKubernetesConfig object

Field	Type	Description
mtu	**integer**	The maximum transmission unit (MTU) for the Geneve (Generic Network Virtualization Encapsulation) overlay network. This is detected automatically based on the MTU of the primary network interface. You do not normally need to override the detected MTU. If the auto-detected value is not what you expect it to be, confirm that the MTU on the primary network interface on your nodes is correct. You cannot use this option to change the MTU value of the primary network interface on the nodes. If your cluster requires different MTU values for different nodes, you must set this value to **100** less than the lowest MTU value in your cluster. For example, if some nodes in your cluster have an MTU of **9001**, and some have an MTU of**1500**, you must set this value to **1400**.
genevePort	**integer**	The port to use for all Geneve packets. The default value is **6081**. This value cannot be changed after cluster installation.
ipsecConfig	**object**	Specify an empty object to enable IPsec encryption.
policyAuditConfig	**object**	Specify a configuration object for customizing network policy audit logging. If unset, the defaults audit log settings are used.
gatewayConfig	**object**	Optional: Specify a configuration object for customizing how egress traffic is sent to the node gateway.  **NOTE** While migrating egress traffic, you can expect some disruption to workloads and service traffic until the Cluster Network Operator (CNO) successfully rolls out the changes.

Table 18.16. **policyAuditConfig** object

Field	Type	Description
rateLimit	integer	The maximum number of messages to generate every second per node. The default value is **20** messages per second.
maxFileSize	integer	The maximum size for the audit log in bytes. The default value is **50000000** or 50 MB.

Field	Type	Description
destination	string	One of the following additional audit log targets: **libc** The libc **syslog()** function of the journald process on the host. **udp:<host>:<port>** A syslog server. Replace **<host>:<port>** with the host and port of the syslog server. **unix:<file>** A Unix Domain Socket file specified by **<file>**. **null** Do not send the audit logs to any additional target.
syslogFacility	string	The syslog facility, such as **kern**, as defined by RFC5424. The default value is **local0**.

Table 18.17. **gatewayConfig** object

Field	Type	Description
routingViaHost	**boolean**	Set this field to **true** to send egress traffic from pods to the host networking stack. For highly-specialized installations and applications that rely on manually configured routes in the kernel routing table, you might want to route egress traffic to the host networking stack. By default, egress traffic is processed in OVN to exit the cluster and is not affected by specialized routes in the kernel routing table. The default value is **false**. This field has an interaction with the Open vSwitch hardware offloading feature. If you set this field to **true**, you do not receive the performance benefits of the offloading because egress traffic is processed by the host networking stack.

Example OVN-Kubernetes configuration with IPSec enabled

```
defaultNetwork:
  type: OVNKubernetes
  ovnKubernetesConfig:
    mtu: 1400
    genevePort: 6081
    ipsecConfig: {}
```

kubeProxyConfig object configuration

The values for the **kubeProxyConfig** object are defined in the following table:

Table 18.18. **kubeProxyConfig** object

Field	Type	Description
iptablesSyncPeriod	**string**	The refresh period for **iptables** rules. The default value is **30s**. Valid suffixes include **s**, **m**, and **h** and are described in the Go **time** package documentation. NOTE Because of performance improvements introduced in OpenShift Container Platform 4.3 and greater, adjusting the **iptablesSyncPeriod** parameter is no longer necessary.
proxyArguments.iptables-min-sync-period	**array**	The minimum duration before refreshing **iptables** rules. This field ensures that the refresh does not happen too frequently. Valid suffixes include **s**, **m**, and **h** and are described in the Go **time** package. The default value is: kubeProxyConfig: proxyArguments: iptables-min-sync-period: - 0s

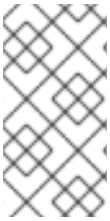
18.2.11. Creating the Kubernetes manifest and Ignition config files

Because you must modify some cluster definition files and manually start the cluster machines, you must generate the Kubernetes manifest and Ignition config files that the cluster needs to configure the machines.

The installation configuration file transforms into the Kubernetes manifests. The manifests wrap into the Ignition configuration files, which are later used to configure the cluster machines.

IMPORTANT

- The Ignition config files that the OpenShift Container Platform installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.



NOTE

The installation program that generates the manifest and Ignition files is architecture specific and can be obtained from the client image mirror. The Linux version of the installation program (without an architecture postfix) runs on ppc64le only. This installer program is also available as a Mac OS version.

Prerequisites

- You obtained the OpenShift Container Platform installation program.
- You created the **install-config.yaml** installation configuration file.

Procedure

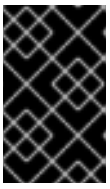
1. Change to the directory that contains the OpenShift Container Platform installation program and generate the Kubernetes manifests for the cluster:

```
$ ./openshift-install create manifests --dir <installation_directory> 1
```

1 For **<installation_directory>**, specify the installation directory that contains the **install-config.yaml** file you created.

WARNING

If you are installing a three-node cluster, skip the following step to allow the control plane nodes to be schedulable.



IMPORTANT

When you configure control plane nodes from the default unschedulable to schedulable, additional subscriptions are required. This is because control plane nodes then become compute nodes.

2. Check that the **mastersSchedulable** parameter in the **<installation_directory>/manifests/cluster-scheduler-02-config.yml** Kubernetes manifest file is set to **false**. This setting prevents pods from being scheduled on the control plane machines:
   a. Open the **<installation_directory>/manifests/cluster-scheduler-02-config.yml** file.
   b. Locate the **mastersSchedulable** parameter and ensure that it is set to **false**.
   c. Save and exit the file.
3. To create the Ignition configuration files, run the following command from the directory that contains the installation program:

```
$ ./openshift-install create ignition-configs --dir <installation_directory> 1
```

1 For **<installation_directory>**, specify the same installation directory.

Ignition config files are created for the bootstrap, control plane, and compute nodes in the installation directory. The **kubeadmin-password** and **kubeconfig** files are created in the **./<installation_directory>/auth** directory:

```
.
├── auth
│   ├── kubeadmin-password
│   └── kubeconfig
├── bootstrap.ign
├── master.ign
├── metadata.json
└── worker.ign
```

18.2.12. Installing RHCOS and starting the OpenShift Container Platform bootstrap process

To install OpenShift Container Platform on IBM Power infrastructure that you provision, you must install Red Hat Enterprise Linux CoreOS (RHCOS) on the machines. When you install RHCOS, you must provide the Ignition config file that was generated by the OpenShift Container Platform installation program for the type of machine you are installing. If you have configured suitable networking, DNS, and load balancing infrastructure, the OpenShift Container Platform bootstrap process begins automatically after the RHCOS machines have rebooted.

Follow either the steps to use an ISO image or network PXE booting to install RHCOS on the machines.

18.2.12.1. Installing RHCOS by using an ISO image

You can use an ISO image to install RHCOS on the machines.

Prerequisites

- You have created the Ignition config files for your cluster.
- You have configured suitable network, DNS and load balancing infrastructure.
- You have an HTTP server that can be accessed from your computer, and from the machines that you create.
- You have reviewed the *Advanced RHCOS installation configuration* section for different ways to configure features, such as networking and disk partitioning.

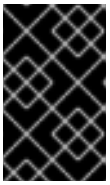
Procedure

1. Obtain the SHA512 digest for each of your Ignition config files. For example, you can use the following on a system running Linux to get the SHA512 digest for your **bootstrap.ign** Ignition config file:

```
$ sha512sum <installation_directory>/bootstrap.ign
```

The digests are provided to the **coreos-installer** in a later step to validate the authenticity of the Ignition config files on the cluster nodes.

2. Upload the bootstrap, control plane, and compute node Ignition config files that the installation program created to your HTTP server. Note the URLs of these files.



IMPORTANT

You can add or change configuration settings in your Ignition configs before saving them to your HTTP server. If you plan to add more compute machines to your cluster after you finish installation, do not delete these files.

3. From the installation host, validate that the Ignition config files are available on the URLs. The following example gets the Ignition config file for the bootstrap node:

```
$ curl -k http://<HTTP_server>/bootstrap.ign 1
```

Example output

```
  % Total    % Received % Xferd  Average Speed   Time    Time     Time  Current
                                 Dload  Upload   Total   Spent    Left  Speed
  0     0    0     0    0     0      0      0 --:--:-- --:--:-- --:--:--     0{"ignition":
{"version":"3.2.0"},"passwd":{"users":[{"name":"core","sshAuthorizedKeys":["ssh-rsa...
```

Replace **bootstrap.ign** with **master.ign** or **worker.ign** in the command to validate that the Ignition config files for the control plane and compute nodes are also available.

4. Although it is possible to obtain the RHCOS images that are required for your preferred method of installing operating system instances from the RHCOS image mirror page, the recommended way to obtain the correct version of your RHCOS images are from the output of **openshift-install** command:

```
$ openshift-install coreos print-stream-json | grep '\.iso[^.]'
```

Example output

```
"location": "<url>/art/storage/releases/rhcos-4.11-aarch64/<release>/aarch64/rhcos-
<release>-live.aarch64.iso",
"location": "<url>/art/storage/releases/rhcos-4.11-ppc64le/<release>/ppc64le/rhcos-
<release>-live.ppc64le.iso",
"location": "<url>/art/storage/releases/rhcos-4.11-s390x/<release>/s390x/rhcos-<release>-
live.s390x.iso",
"location": "<url>/art/storage/releases/rhcos-4.11/<release>/x86_64/rhcos-<release>-
live.x86_64.iso",
```

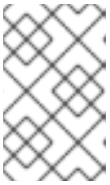
IMPORTANT

The RHCOS images might not change with every release of OpenShift Container Platform. You must download images with the highest version that is less than or equal to the OpenShift Container Platform version that you install. Use the image versions that match your OpenShift Container Platform version if they are available. Use only ISO images for this procedure. RHCOS qcow2 images are not supported for this installation type.

ISO file names resemble the following example:

rhcos-<version>-live.<architecture>.iso

5. Use the ISO to start the RHCOS installation. Use one of the following installation options:
   - Burn the ISO image to a disk and boot it directly.
   - Use ISO redirection by using a lights-out management (LOM) interface.
6. Boot the RHCOS ISO image without specifying any options or interrupting the live boot sequence. Wait for the installer to boot into a shell prompt in the RHCOS live environment.



NOTE

It is possible to interrupt the RHCOS installation boot process to add kernel arguments. However, for this ISO procedure you should use the **coreos-installer** command as outlined in the following steps, instead of adding kernel arguments.

7. Run the **coreos-installer** command and specify the options that meet your installation requirements. At a minimum, you must specify the URL that points to the Ignition config file for the node type, and the device that you are installing to:

```
$ sudo coreos-installer install --ignition-url=http://<HTTP_server>/<node_type>.ign <device>
--ignition-hash=sha512-<digest> 1 2
```

1 1 You must run the **coreos-installer** command by using **sudo**, because the **core** user does not have the required root privileges to perform the installation.

2 The **--ignition-hash** option is required when the Ignition config file is obtained through an HTTP URL to validate the authenticity of the Ignition config file on the cluster node. **<digest>** is the Ignition config file SHA512 digest obtained in a preceding step.

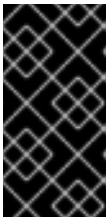
NOTE

If you want to provide your Ignition config files through an HTTPS server that uses TLS, you can add the internal certificate authority (CA) to the system trust store before running **coreos-installer**.

The following example initializes a bootstrap node installation to the **/dev/sda** device. The Ignition config file for the bootstrap node is obtained from an HTTP web server with the IP address 192.168.1.2:

```
$ sudo coreos-installer install --ignition-
url=http://192.168.1.2:80/installation_directory/bootstrap.ign /dev/sda --ignition-hash=sha512-
a5a2d43879223273c9b60af66b44202a1d1248fc01cf156c46d4a79f552b6bad47bc8cc78ddf011
6e80c59d2ea9e32ba53bc807afbca581aa059311def2c3e3b
```

8. Monitor the progress of the RHCOS installation on the console of the machine.



IMPORTANT

Be sure that the installation is successful on each node before commencing with the OpenShift Container Platform installation. Observing the installation process can also help to determine the cause of RHCOS installation issues that might arise.

9. After RHCOS installs, you must reboot the system. During the system reboot, it applies the Ignition config file that you specified.

10. Check the console output to verify that Ignition ran.

Example command

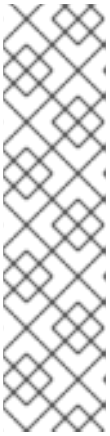
```
Ignition: ran on 2022/03/14 14:48:33 UTC (this boot)
Ignition: user-provided config was applied
```

11. Continue to create the other machines for your cluster.

IMPORTANT

You must create the bootstrap and control plane machines at this time. If the control plane machines are not made schedulable, also create at least two compute machines before you install OpenShift Container Platform.

If the required network, DNS, and load balancer infrastructure are in place, the OpenShift Container Platform bootstrap process begins automatically after the RHCOS nodes have rebooted.



NOTE

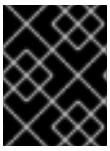
RHCOS nodes do not include a default password for the **core** user. You can access the nodes by running **ssh core@<node>.<cluster_name>.<base_domain>** as a user with access to the SSH private key that is paired to the public key that you specified in your **install_config.yaml** file. OpenShift Container Platform 4 cluster nodes running RHCOS are immutable and rely on Operators to apply cluster changes. Accessing cluster nodes by using SSH is not recommended. However, when investigating installation issues, if the OpenShift Container Platform API is not available, or the kubelet is not properly functioning on a target node, SSH access might be required for debugging or disaster recovery.

18.2.12.1.1. Advanced RHCOS installation reference

This section illustrates the networking configuration and other advanced options that allow you to modify the Red Hat Enterprise Linux CoreOS (RHCOS) manual installation process. The following tables describe the kernel arguments and command-line options you can use with the RHCOS live installer and the **coreos-installer** command.

18.2.12.1.1.1. Networking and bonding options for ISO installations

If you install RHCOS from an ISO image, you can add kernel arguments manually when you boot the image to configure networking for a node. If no networking arguments are specified, DHCP is activated in the initramfs when RHCOS detects that networking is required to fetch the Ignition config file.



IMPORTANT

When adding networking arguments manually, you must also add the **rd.neednet=1** kernel argument to bring the network up in the initramfs.

The following information provides examples for configuring networking and bonding on your RHCOS nodes for ISO installations. The examples describe how to use the **ip=**, **nameserver=**, and **bond=** kernel arguments.

NOTE

Ordering is important when adding the kernel arguments: **ip=**, **nameserver=**, and then **bond=**.

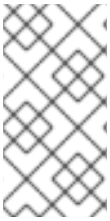
The networking options are passed to the **dracut** tool during system boot. For more information about the networking options supported by **dracut**, see the **dracut.cmdline** manual page.

The following examples are the networking options for ISO installation.

Configuring DHCP or static IP addresses
To configure an IP address, either use DHCP (**ip=dhcp**) or set an individual static IP address (**ip=<host_ip>**). If setting a static IP, you must then identify the DNS server IP address (**nameserver=<dns_ip>**) on each node. The following example sets:

- The node's IP address to **10.10.10.2**
- The gateway address to **10.10.10.254**
- The netmask to **255.255.255.0**
- The hostname to **core0.example.com**
- The DNS server address to **4.4.4.41**
- The auto-configuration value to **none**. No auto-configuration is required when IP networking is configured statically.

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp1s0:none
nameserver=4.4.4.41
```



NOTE

When you use DHCP to configure IP addressing for the RHCOS machines, the machines also obtain the DNS server information through DHCP. For DHCP-based deployments, you can define the DNS server address that is used by the RHCOS nodes through your DHCP server configuration.

Configuring an IP address without a static hostname
You can configure an IP address without assigning a static hostname. If a static hostname is not set by the user, it will be picked up and automatically set by a reverse DNS lookup. To configure an IP address without a static hostname refer to the following example:

- The node's IP address to **10.10.10.2**

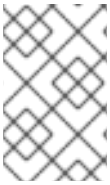
- The gateway address to **10.10.10.254**
- The netmask to **255.255.255.0**
- The DNS server address to **4.4.4.41**
- The auto-configuration value to **none**. No auto-configuration is required when IP networking is configured statically.

```
ip=10.10.10.2::10.10.10.254:255.255.255.0::enp1s0:none
nameserver=4.4.4.41
```

Specifying multiple network interfaces
You can specify multiple network interfaces by setting multiple **ip=** entries.

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp1s0:none
ip=10.10.10.3::10.10.10.254:255.255.255.0:core0.example.com:enp2s0:none
```

Configuring default gateway and route
Optional: You can configure routes to additional networks by setting an **rd.route=** value.



NOTE

When you configure one or multiple networks, one default gateway is required. If the additional network gateway is different from the primary network gateway, the default gateway must be the primary network gateway.

- Run the following command to configure the default gateway:

```
ip=::10.10.10.254::::
```

- Enter the following command to configure the route for the additional network:

```
rd.route=20.20.20.0/24:20.20.20.254:enp2s0
```

Disabling DHCP on a single interface
You can disable DHCP on a single interface, such as when there are two or more network interfaces and only one interface is being used. In the example, the **enp1s0** interface has a static networking configuration and DHCP is disabled for **enp2s0**, which is not used:

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp1s0:none
ip=::::core0.example.com:enp2s0:none
```

Combining DHCP and static IP configurations
You can combine DHCP and static IP configurations on systems with multiple network interfaces, for example:

```
ip=enp1s0:dhcp
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp2s0:none
```

Configuring VLANs on individual interfaces
Optional: You can configure VLANs on individual interfaces by using the **vlan=** parameter.

- To configure a VLAN on a network interface and use a static IP address, run the following command:

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp2s0.100:none
vlan=enp2s0.100:enp2s0
```

- To configure a VLAN on a network interface and to use DHCP, run the following command:

```
ip=enp2s0.100:dhcp
vlan=enp2s0.100:enp2s0
```

Providing multiple DNS servers
You can provide multiple DNS servers by adding a **nameserver=** entry for each server, for example:

```
nameserver=1.1.1.1
nameserver=8.8.8.8
```

Bonding multiple network interfaces to a single interface
Optional: You can bond multiple network interfaces to a single interface by using the **bond=** option. Refer to the following examples:

- The syntax for configuring a bonded interface is: **bond=name[:network_interfaces][:options]** *name* is the bonding device name (**bond0**), *network_interfaces* represents a comma-separated list of physical (ethernet) interfaces (**em1,em2**), and *options* is a comma-separated list of bonding options. Enter **modinfo bonding** to see available options.

- When you create a bonded interface using **bond=**, you must specify how the IP address is assigned and other information for the bonded interface.

- To configure the bonded interface to use DHCP, set the bond's IP address to **dhcp**. For example:

```
bond=bond0:em1,em2:mode=active-backup
ip=bond0:dhcp
```

- To configure the bonded interface to use a static IP address, enter the specific IP address you want and related information. For example:

```
bond=bond0:em1,em2:mode=active-backup
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:bond0:none
```

Bonding multiple network interfaces to a single interface
Optional: You can configure VLANs on bonded interfaces by using the **vlan=** parameter and to use DHCP, for example:

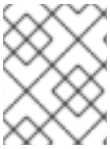
```
ip=bond0.100:dhcp
bond=bond0:em1,em2:mode=active-backup
vlan=bond0.100:bond0
```

Use the following example to configure the bonded interface with a VLAN and to use a static IP address:

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:bond0.100:none
bond=bond0:em1,em2:mode=active-backup
vlan=bond0.100:bond0
```

Using network teaming
Optional: You can use a network teaming as an alternative to bonding by using the **team=** parameter:

- The syntax for configuring a team interface is: **team=name[:network_interfaces]**
  name is the team device name (**team0**) and *network_interfaces* represents a comma-separated list of physical (ethernet) interfaces (**em1, em2**).



NOTE

Teaming is planned to be deprecated when RHCOS switches to an upcoming version of RHEL. For more information, see this Red Hat Knowledgebase Article .

Use the following example to configure a network team:

```
team=team0:em1,em2
ip=team0:dhcp
```

18.2.12.2. Installing RHCOS by using PXE booting

You can use PXE booting to install RHCOS on the machines.

Prerequisites

- You have created the Ignition config files for your cluster.
- You have configured suitable network, DNS and load balancing infrastructure.
- You have configured suitable PXE infrastructure.
- You have an HTTP server that can be accessed from your computer, and from the machines that you create.
- You have reviewed the *Advanced RHCOS installation configuration* section for different ways to configure features, such as networking and disk partitioning.

Procedure

1. Upload the bootstrap, control plane, and compute node Ignition config files that the installation program created to your HTTP server. Note the URLs of these files.

IMPORTANT

You can add or change configuration settings in your Ignition configs before saving them to your HTTP server. If you plan to add more compute machines to your cluster after you finish installation, do not delete these files.

2. From the installation host, validate that the Ignition config files are available on the URLs. The following example gets the Ignition config file for the bootstrap node:

```
$ curl -k http://<HTTP_server>/bootstrap.ign 1
```

Example output

```
  % Total    % Received % Xferd  Average Speed   Time    Time     Time  Current
                                 Dload  Upload   Total   Spent    Left  Speed
  0     0    0     0    0     0      0      0 --:--:-- --:--:-- --:--:--     0{"ignition":
{"version":"3.2.0"},"passwd":{"users":[{"name":"core","sshAuthorizedKeys":["ssh-rsa...
```

Replace **bootstrap.ign** with **master.ign** or **worker.ign** in the command to validate that the Ignition config files for the control plane and compute nodes are also available.

3. Although it is possible to obtain the RHCOS **kernel**, **initramfs** and **rootfs** files that are required for your preferred method of installing operating system instances from the RHCOS image mirror page, the recommended way to obtain the correct version of your RHCOS files are from the output of **openshift-install** command:

```
$ openshift-install coreos print-stream-json | grep -Eo '"https.*(kernel-|initramfs.|rootfs.)\w+(\.img)?"'
```

Example output

```
"<url>/art/storage/releases/rhcos-4.11-aarch64/<release>/aarch64/rhcos-<release>-live-kernel-aarch64"
"<url>/art/storage/releases/rhcos-4.11-aarch64/<release>/aarch64/rhcos-<release>-live-initramfs.aarch64.img"
"<url>/art/storage/releases/rhcos-4.11-aarch64/<release>/aarch64/rhcos-<release>-live-rootfs.aarch64.img"
"<url>/art/storage/releases/rhcos-4.11-ppc64le/49.84.202110081256-0/ppc64le/rhcos-<release>-live-kernel-ppc64le"
"<url>/art/storage/releases/rhcos-4.11-ppc64le/<release>/ppc64le/rhcos-<release>-live-initramfs.ppc64le.img"
"<url>/art/storage/releases/rhcos-4.11-ppc64le/<release>/ppc64le/rhcos-<release>-live-rootfs.ppc64le.img"
"<url>/art/storage/releases/rhcos-4.11-s390x/<release>/s390x/rhcos-<release>-live-kernel-s390x"
"<url>/art/storage/releases/rhcos-4.11-s390x/<release>/s390x/rhcos-<release>-live-initramfs.s390x.img"
"<url>/art/storage/releases/rhcos-4.11-s390x/<release>/s390x/rhcos-<release>-live-rootfs.s390x.img"
"<url>/art/storage/releases/rhcos-4.11/<release>/x86_64/rhcos-<release>-live-kernel-x86_64"
"<url>/art/storage/releases/rhcos-4.11/<release>/x86_64/rhcos-<release>-live-initramfs.x86_64.img"
"<url>/art/storage/releases/rhcos-4.11/<release>/x86_64/rhcos-<release>-live-rootfs.x86_64.img"
```

IMPORTANT

The RHCOS artifacts might not change with every release of OpenShift Container Platform. You must download images with the highest version that is less than or equal to the OpenShift Container Platform version that you install. Only use the appropriate **kernel**, **initramfs**, and **rootfs** artifacts described below for this procedure. RHCOS QCOW2 images are not supported for this installation type.

The file names contain the OpenShift Container Platform version number. They resemble the following examples:

- **kernel**: **rhcos-<version>-live-kernel-<architecture>**
- **initramfs**: **rhcos-<version>-live-initramfs.<architecture>.img**
- **rootfs**: **rhcos-<version>-live-rootfs.<architecture>.img**

4. Upload the **rootfs**, **kernel**, and **initramfs** files to your HTTP server.

IMPORTANT

If you plan to add more compute machines to your cluster after you finish installation, do not delete these files.

5. Configure the network boot infrastructure so that the machines boot from their local disks after RHCOS is installed on them.

6. Configure PXE installation for the RHCOS images and begin the installation.
Modify the following example menu entry for your environment and verify that the image and Ignition files are properly accessible:

```
DEFAULT pxeboot
TIMEOUT 20
PROMPT 0
LABEL pxeboot
    KERNEL http://<HTTP_server>/rhcos-<version>-live-kernel-<architecture> (1)
    APPEND initrd=http://<HTTP_server>/rhcos-<version>-live-initramfs.<architecture>.img
coreos.live.rootfs_url=http://<HTTP_server>/rhcos-<version>-live-rootfs.<architecture>.img
coreos.inst.install_dev=/dev/sda coreos.inst.ignition_url=http://<HTTP_server>/bootstrap.ign
(2) (3)
```

(1) (1) Specify the location of the live **kernel** file that you uploaded to your HTTP server. The URL must be HTTP, TFTP, or FTP; HTTPS and NFS are not supported.

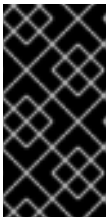
(2) If you use multiple NICs, specify a single interface in the **ip** option. For example, to use DHCP on a NIC that is named **eno1**, set **ip=eno1:dhcp**.

(3) Specify the locations of the RHCOS files that you uploaded to your HTTP server. The **initrd** parameter value is the location of the **initramfs** file, the **coreos.live.rootfs_url** parameter value is the location of the **rootfs** file, and the **coreos.inst.ignition_url** parameter value is the location of the bootstrap Ignition config file. You can also add more kernel arguments to the **APPEND** line to configure networking or other boot options.

NOTE

This configuration does not enable serial console access on machines with a graphical console. To configure a different console, add one or more **console=** arguments to the **APPEND** line. For example, add **console=tty0 console=ttyS0** to set the first PC serial port as the primary console and the graphical console as a secondary console. For more information, see How does one set up a serial terminal and/or console in Red Hat Enterprise Linux?.

7. Monitor the progress of the RHCOS installation on the console of the machine.



IMPORTANT

Be sure that the installation is successful on each node before commencing with the OpenShift Container Platform installation. Observing the installation process can also help to determine the cause of RHCOS installation issues that might arise.

8. After RHCOS installs, the system reboots. During reboot, the system applies the Ignition config file that you specified.

9. Check the console output to verify that Ignition ran.

Example command

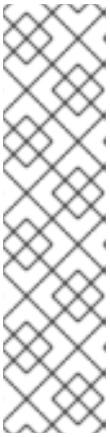
```
Ignition: ran on 2022/03/14 14:48:33 UTC (this boot)
Ignition: user-provided config was applied
```

10. Continue to create the machines for your cluster.

IMPORTANT

You must create the bootstrap and control plane machines at this time. If the control plane machines are not made schedulable, also create at least two compute machines before you install the cluster.

If the required network, DNS, and load balancer infrastructure are in place, the OpenShift Container Platform bootstrap process begins automatically after the RHCOS nodes have rebooted.



NOTE

RHCOS nodes do not include a default password for the **core** user. You can access the nodes by running **ssh core@<node>.<cluster_name>.<base_domain>** as a user with access to the SSH private key that is paired to the public key that you specified in your **install_config.yaml** file. OpenShift Container Platform 4 cluster nodes running RHCOS are immutable and rely on Operators to apply cluster changes. Accessing cluster nodes by using SSH is not recommended. However, when investigating installation issues, if the OpenShift Container Platform API is not available, or the kubelet is not properly functioning on a target node, SSH access might be required for debugging or disaster recovery.

18.2.12.3. Enabling multipathing with kernel arguments on RHCOS

In OpenShift Container Platform 4.9 or later, during installation, you can enable multipathing for provisioned nodes. RHCOS supports multipathing on the primary disk. Multipathing provides added benefits of stronger resilience to hardware failure to achieve higher host availability.

During the initial cluster creation, you might want to add kernel arguments to all master or worker nodes. To add kernel arguments to master or worker nodes, you can create a **MachineConfig** object and inject that object into the set of manifest files used by Ignition during cluster setup.

Procedure

1. Change to the directory that contains the installation program and generate the Kubernetes manifests for the cluster:

```
$ ./openshift-install create manifests --dir <installation_directory>
```

2. Decide if you want to add kernel arguments to worker or control plane nodes.

   - Create a machine config file. For example, create a **99-master-kargs-mpath.yaml** that instructs the cluster to add the **master** label and identify the multipath kernel argument:

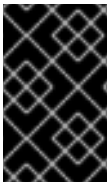
```
apiVersion: machineconfiguration.openshift.io/v1
kind: MachineConfig
metadata:
  labels:
    machineconfiguration.openshift.io/role: "master"
  name: 99-master-kargs-mpath
spec:
  kernelArguments:
    - 'rd.multipath=default'
    - 'root=/dev/disk/by-label/dm-mpath-root'
```

3. To enable multipathing on worker nodes:

   - Create a machine config file. For example, create a **99-worker-kargs-mpath.yaml** that instructs the cluster to add the **worker** label and identify the multipath kernel argument:

```
apiVersion: machineconfiguration.openshift.io/v1
kind: MachineConfig
metadata:
  labels:
    machineconfiguration.openshift.io/role: "worker"
  name: 99-worker-kargs-mpath
spec:
  kernelArguments:
    - 'rd.multipath=default'
    - 'root=/dev/disk/by-label/dm-mpath-root'
```

   You can now continue on to create the cluster.



IMPORTANT

Additional postinstallation steps are required to fully enable multipathing. For more information, see “Enabling multipathing with kernel arguments on RHCOS" in *Postinstallation machine configuration tasks*.

In case of MPIO failure, use the bootlist command to update the boot device list with alternate logical device names. The command displays a boot list and it designates the possible boot devices for when the system is booted in normal mode.

a. To display a boot list and specify the possible boot devices if the system is booted in normal mode, enter the following command:

```
$ bootlist -m normal -o
sda
```

b. To update the boot list for normal mode and add alternate device names, enter the following command:

```
$ bootlist -m normal -o /dev/sdc /dev/sdd /dev/sde
sdc
sdd
sde
```

If the original boot disk path is down, the node reboots from the alternate device registered in the normal boot device list.

18.2.13. Waiting for the bootstrap process to complete

The OpenShift Container Platform bootstrap process begins after the cluster nodes first boot into the persistent RHCOS environment that has been installed to disk. The configuration information provided through the Ignition config files is used to initialize the bootstrap process and install OpenShift Container Platform on the machines. You must wait for the bootstrap process to complete.

Prerequisites

- You have created the Ignition config files for your cluster.
- You have configured suitable network, DNS and load balancing infrastructure.
- You have obtained the installation program and generated the Ignition config files for your cluster.
- You installed RHCOS on your cluster machines and provided the Ignition config files that the OpenShift Container Platform installation program generated.
- Your machines have direct internet access or have an HTTP or HTTPS proxy available.

Procedure

1. Monitor the bootstrap process:

```
$ ./openshift-install --dir <installation_directory> wait-for bootstrap-complete \ 1
    --log-level=info 2
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

Example output

```
INFO Waiting up to 30m0s for the Kubernetes API at https://api.test.example.com:6443...
INFO API v1.24.0 up
INFO Waiting up to 30m0s for bootstrapping to complete...
INFO It is now safe to remove the bootstrap resources
```

The command succeeds when the Kubernetes API server signals that it has been bootstrapped on the control plane machines.

2. After the bootstrap process is complete, remove the bootstrap machine from the load balancer.

IMPORTANT

You must remove the bootstrap machine from the load balancer at this point. You can also remove or reformat the bootstrap machine itself.

18.2.14. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

Example output

```
system:admin
```

18.2.15. Approving the certificate signing requests for your machines

When you add machines to a cluster, two pending certificate signing requests (CSRs) are generated for each machine that you added. You must confirm that these CSRs are approved or, if necessary, approve them yourself. The client requests must be approved first, followed by the server requests.

Prerequisites

- You added machines to your cluster.

Procedure

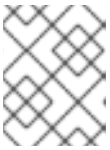
1. Confirm that the cluster recognizes the machines:

```
$ oc get nodes
```

Example output

```
NAME      STATUS    ROLES   AGE  VERSION
master-0  Ready     master  63m  v1.24.0
master-1  Ready     master  63m  v1.24.0
master-2  Ready     master  64m  v1.24.0
```

The output lists all of the machines that you created.



NOTE

The preceding output might not include the compute nodes, also known as worker nodes, until some CSRs are approved.

2. Review the pending CSRs and ensure that you see the client requests with the **Pending** or **Approved** status for each machine that you added to the cluster:

```
$ oc get csr
```

Example output

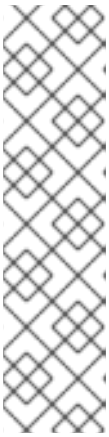
```
NAME        AGE     REQUESTOR                                                   CONDITION
csr-8b2br   15m     system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper   Pending
csr-8vnps   15m     system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper   Pending
...
```

In this example, two machines are joining the cluster. You might see more approved CSRs in the list.

3. If the CSRs were not approved, after all of the pending CSRs for the machines you added are in **Pending** status, approve the CSRs for your cluster machines:

NOTE

Because the CSRs rotate automatically, approve your CSRs within an hour of adding the machines to the cluster. If you do not approve them within an hour, the certificates will rotate, and more than two certificates will be present for each node. You must approve all of these certificates. After the client CSR is approved, the Kubelet creates a secondary CSR for the serving certificate, which requires manual approval. Then, subsequent serving certificate renewal requests are automatically approved by the **machine-approver** if the Kubelet requests a new certificate with identical parameters.



NOTE

For clusters running on platforms that are not machine API enabled, such as bare metal and other user-provisioned infrastructure, you must implement a method of automatically approving the kubelet serving certificate requests (CSRs). If a request is not approved, then the **oc exec**, **oc rsh**, and **oc logs** commands cannot succeed, because a serving certificate is required when the API server connects to the kubelet. Any operation that contacts the Kubelet endpoint requires this certificate approval to be in place. The method must watch for new CSRs, confirm that the CSR was submitted by the **node-bootstrapper** service account in the **system:node** or **system:admin** groups, and confirm the identity of the node.

- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

1 **<csr_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{{"\n"}}
{{end}}{{end}}' | xargs --no-run-if-empty oc adm certificate approve
```

NOTE

Some Operators might not become available until some CSRs are approved.

4. Now that your client requests are approved, you must review the server requests for each machine that you added to the cluster:

```
$ oc get csr
```

Example output

```
NAME        AGE     REQUESTOR                                                   CONDITION
csr-bfd72   5m26s   system:node:ip-10-0-50-126.us-east-2.compute.internal
Pending
csr-c57lv   5m26s   system:node:ip-10-0-95-157.us-east-2.compute.internal
Pending
...
```

5. If the remaining CSRs are not approved, and are in the **Pending** status, approve the CSRs for your cluster machines:

   - To approve them individually, run the following command for each valid CSR:

     ```
     $ oc adm certificate approve <csr_name> 1
     ```

     1 **<csr_name>** is the name of a CSR from the list of current CSRs.

   - To approve all pending CSRs, run the following command:

     ```
     $ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{{"\n"}}
     {{end}}{{end}}' | xargs oc adm certificate approve
     ```

6. After all client and server CSRs have been approved, the machines have the **Ready** status. Verify this by running the following command:

   ```
   $ oc get nodes
   ```

   Example output

   ```
   NAME      STATUS    ROLES   AGE  VERSION
   master-0  Ready     master  73m  v1.24.0
   master-1  Ready     master  73m  v1.24.0
   master-2  Ready     master  74m  v1.24.0
   worker-0  Ready     worker  11m  v1.24.0
   worker-1  Ready     worker  11m  v1.24.0
   ```

   NOTE

   It can take a few minutes after approval of the server CSRs for the machines to transition to the **Ready** status.

Additional information

- For more information on CSRs, see Certificate Signing Requests.

18.2.16. Initial Operator configuration

After the control plane initializes, you must immediately configure some Operators so that they all become available.

Prerequisites

- Your control plane has initialized.

Procedure

1. Watch the cluster components come online:

   ```
   $ watch -n5 oc get clusteroperators
   ```

Example output

```
NAME                                       VERSION   AVAILABLE   PROGRESSING   DEGRADED
SINCE
authentication                             4.11.0    True        False         False      19m
baremetal                                  4.11.0    True        False         False      37m
cloud-credential                           4.11.0    True        False         False      40m
cluster-autoscaler                         4.11.0    True        False         False      37m
config-operator                            4.11.0    True        False         False      38m
console                                    4.11.0    True        False         False      26m
csi-snapshot-controller                    4.11.0    True        False         False      37m
dns                                        4.11.0    True        False         False      37m
etcd                                       4.11.0    True        False         False      36m
image-registry                             4.11.0    True        False         False      31m
ingress                                    4.11.0    True        False         False      30m
insights                                   4.11.0    True        False         False      31m
kube-apiserver                             4.11.0    True        False         False      26m
kube-controller-manager                    4.11.0    True        False         False      36m
kube-scheduler                             4.11.0    True        False         False      36m
kube-storage-version-migrator              4.11.0    True        False         False      37m
machine-api                                4.11.0    True        False         False      29m
machine-approver                           4.11.0    True        False         False      37m
machine-config                             4.11.0    True        False         False      36m
marketplace                                4.11.0    True        False         False      37m
monitoring                                 4.11.0    True        False         False      29m
network                                    4.11.0    True        False         False      38m
node-tuning                                4.11.0    True        False         False      37m
openshift-apiserver                        4.11.0    True        False         False      32m
openshift-controller-manager               4.11.0    True        False         False      30m
openshift-samples                          4.11.0    True        False         False      32m
operator-lifecycle-manager                 4.11.0    True        False         False      37m
operator-lifecycle-manager-catalog         4.11.0    True        False         False      37m
operator-lifecycle-manager-packageserver   4.11.0    True        False         False      32m
service-ca                                 4.11.0    True        False         False      38m
storage                                    4.11.0    True        False         False      37m
```

2. Configure the Operators that are not available.

18.2.16.1. Image registry storage configuration

The Image Registry Operator is not initially available for platforms that do not provide default storage. After installation, you must configure your registry to use storage so that the Registry Operator is made available.

Instructions are shown for configuring a persistent volume, which is required for production clusters. Where applicable, instructions are shown for configuring an empty directory as the storage location, which is available for only non-production clusters.

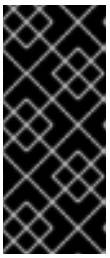
Additional instructions are provided for allowing the image registry to use block storage types by using the **Recreate** rollout strategy during upgrades.

18.2.16.1.1. Configuring registry storage for IBM Power

As a cluster administrator, following installation you must configure your registry to use storage.

Prerequisites

- You have access to the cluster as a user with the **cluster-admin** role.
- You have a cluster on IBM Power.
- You have provisioned persistent storage for your cluster, such as Red Hat OpenShift Data Foundation.



IMPORTANT

OpenShift Container Platform supports **ReadWriteOnce** access for image registry storage when you have only one replica. **ReadWriteOnce** access also requires that the registry uses the **Recreate** rollout strategy. To deploy an image registry that supports high availability with two or more replicas, **ReadWriteMany** access is required.

- Must have 100Gi capacity.

Procedure

1. To configure your registry to use storage, change the **spec.storage.pvc** in the **configs.imageregistry/cluster** resource.

NOTE

When you use shared storage, review your security settings to prevent outside access.

2. Verify that you do not have a registry pod:

```
$ oc get pod -n openshift-image-registry -l docker-registry=default
```

Example output

```
No resourses found in openshift-image-registry namespace
```

NOTE

If you do have a registry pod in your output, you do not need to continue with this procedure.

3. Check the registry configuration:

```
$ oc edit configs.imageregistry.operator.openshift.io
```

Example output

```
storage:
  pvc:
    claim:
```

Leave the **claim** field blank to allow the automatic creation of an **image-registry-storage** PVC.

4. Check the **clusteroperator** status:

```
$ oc get clusteroperator image-registry
```

Example output

```
NAME             VERSION       AVAILABLE   PROGRESSING   DEGRADED   SINCE
MESSAGE
image-registry   4.11          True        False         False      6h50m
```

5. Ensure that your registry is set to managed to enable building and pushing of images.

- Run:

```
$ oc edit configs.imageregistry/cluster
```

Then, change the line

```
managementState: Removed
```

to

```
managementState: Managed
```

18.2.16.1.2. Configuring storage for the image registry in non-production clusters

You must configure storage for the Image Registry Operator. For non-production clusters, you can set the image registry to an empty directory. If you do so, all images are lost if you restart the registry.

Procedure

- To set the image registry storage to an empty directory:

```
$ oc patch configs.imageregistry.operator.openshift.io cluster --type merge --patch '{"spec":
{"storage":{"emptyDir":{}}}}'
```

WARNING

Configure this option for only non-production clusters.

If you run this command before the Image Registry Operator initializes its components, the **oc patch** command fails with the following error:

```
Error from server (NotFound): configs.imageregistry.operator.openshift.io "cluster" not found
```

Wait a few minutes and run the command again.

18.2.17. Completing installation on user-provisioned infrastructure

After you complete the Operator configuration, you can finish installing the cluster on infrastructure that you provide.

Prerequisites

- Your control plane has initialized.
- You have completed the initial Operator configuration.

Procedure

1. Confirm that all the cluster components are online with the following command:

```
$ watch -n5 oc get clusteroperators
```

Example output

```
NAME                                       VERSION   AVAILABLE   PROGRESSING   DEGRADED
SINCE
authentication                             4.11.0    True        False         False      19m
baremetal                                  4.11.0    True        False         False      37m
cloud-credential                           4.11.0    True        False         False      40m
cluster-autoscaler                         4.11.0    True        False         False      37m
config-operator                            4.11.0    True        False         False      38m
console                                    4.11.0    True        False         False      26m
csi-snapshot-controller                    4.11.0    True        False         False      37m
dns                                        4.11.0    True        False         False      37m
etcd                                       4.11.0    True        False         False      36m
image-registry                             4.11.0    True        False         False      31m
ingress                                    4.11.0    True        False         False      30m
insights                                   4.11.0    True        False         False      31m
kube-apiserver                             4.11.0    True        False         False      26m
kube-controller-manager                    4.11.0    True        False         False      36m
kube-scheduler                             4.11.0    True        False         False      36m
kube-storage-version-migrator              4.11.0    True        False         False      37m
machine-api                                4.11.0    True        False         False      29m
machine-approver                           4.11.0    True        False         False      37m
machine-config                             4.11.0    True        False         False      36m
marketplace                                4.11.0    True        False         False      37m
monitoring                                 4.11.0    True        False         False      29m
network                                    4.11.0    True        False         False      38m
node-tuning                                4.11.0    True        False         False      37m
openshift-apiserver                        4.11.0    True        False         False      32m
openshift-controller-manager               4.11.0    True        False         False      30m
openshift-samples                          4.11.0    True        False         False      32m
operator-lifecycle-manager                 4.11.0    True        False         False      37m
operator-lifecycle-manager-catalog         4.11.0    True        False         False      37m
operator-lifecycle-manager-packageserver   4.11.0    True        False         False      32m
service-ca                                 4.11.0    True        False         False      38m
storage                                    4.11.0    True        False         False      37m
```

Alternatively, the following command notifies you when all of the clusters are available. It also retrieves and displays credentials:

```
$ ./openshift-install --dir <installation_directory> wait-for install-complete 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

Example output

```
INFO Waiting up to 30m0s for the cluster to initialize...
```

The command succeeds when the Cluster Version Operator finishes deploying the OpenShift Container Platform cluster from Kubernetes API server.

IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

2. Confirm that the Kubernetes API server is communicating with the pods.

   a. To view a list of all pods, use the following command:

   ```
   $ oc get pods --all-namespaces
   ```

   ### Example output

   ```
   NAMESPACE                       NAME                                         READY   STATUS
   RESTARTS   AGE
   openshift-apiserver-operator    openshift-apiserver-operator-85cb746d55-zqhs8   1/1
   Running   1          9m
   openshift-apiserver             apiserver-67b9g                              1/1     Running   0
   3m
   openshift-apiserver             apiserver-ljcmx                              1/1     Running   0
   1m
   openshift-apiserver             apiserver-z25h4                              1/1     Running   0
   2m
   openshift-authentication-operator authentication-operator-69d5d8bf84-vh2n8   1/1
   Running   0          5m
   ...
   ```

–

b. View the logs for a pod that is listed in the output of the previous command by using the following command:

```
$ oc logs <pod_name> -n <namespace> 1
```

1 Specify the pod name and namespace, as shown in the output of the previous command.

If the pod logs display, the Kubernetes API server can communicate with the cluster machines.

3. Additional steps are required to enable multipathing. Do not enable multipathing during installation.
See "Enabling multipathing with kernel arguments on RHCOS" in the *Post-installation machine configuration tasks* documentation for more information.

18.2.18. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.11, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to OpenShift Cluster Manager Hybrid Cloud Console.

After you confirm that your OpenShift Cluster Manager Hybrid Cloud Console inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, use subscription watch to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

Additional resources

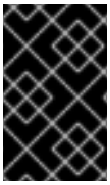
- See About remote health monitoring for more information about the Telemetry service

18.2.19. Next steps

- Enabling multipathing with kernel arguments on RHCOS .
- Customize your cluster.
- If necessary, you can opt out of remote health reporting .

18.3. INSTALLING A CLUSTER ON IBM POWER IN A RESTRICTED NETWORK

In OpenShift Container Platform version 4.11, you can install a cluster on IBM Power infrastructure that you provision in a restricted network.



IMPORTANT

Additional considerations exist for non-bare metal platforms. Review the information in the guidelines for deploying OpenShift Container Platform on non-tested platforms before you install an OpenShift Container Platform cluster.

18.3.1. Prerequisites

- You reviewed details about the OpenShift Container Platform installation and update processes.
- You read the documentation on selecting a cluster installation method and preparing it for users.
- You created a mirror registry for installation in a restricted network and obtained the **imageContentSources** data for your version of OpenShift Container Platform.
- Before you begin the installation process, you must move or remove any existing installation files. This ensures that the required installation files are created and updated during the installation process.

IMPORTANT

Ensure that installation steps are performed on a machine with access to the installation media.

- You provisioned persistent storage using OpenShift Data Foundation or other supported storage protocols for your cluster. To deploy a private image registry, you must set up persistent storage with **ReadWriteMany** access.
- If you use a firewall and plan to use the Telemetry service, you configured the firewall to allow the sites that your cluster requires access to.

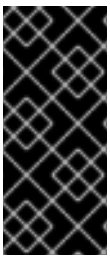
NOTE

Be sure to also review this site list if you are configuring a proxy.

18.3.2. About installations in restricted networks

In OpenShift Container Platform 4.11, you can perform an installation that does not require an active connection to the internet to obtain software components. Restricted network installations can be completed using installer-provisioned infrastructure or user-provisioned infrastructure, depending on the cloud platform to which you are installing the cluster.

To complete a restricted network installation, you must create a registry that mirrors the contents of the OpenShift image registry and contains the installation media. You can create this registry on a mirror host, which can access both the internet and your closed network, or by using other methods that meet your restrictions.



IMPORTANT

Because of the complexity of the configuration for user-provisioned installations, consider completing a standard user-provisioned infrastructure installation before you attempt a restricted network installation using user-provisioned infrastructure. Completing this test installation might make it easier to isolate and troubleshoot any issues that might arise during your installation in a restricted network.

18.3.2.1. Additional limits

Clusters in restricted networks have the following additional limitations and restrictions:

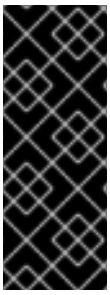
- The **ClusterVersion** status includes an **Unable to retrieve available updates** error.
- By default, you cannot use the contents of the Developer Catalog because you cannot access the required image stream tags.

18.3.3. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.11, you require access to the internet to obtain the images that are necessary to install your cluster.

You must have internet access to:

- Access OpenShift Cluster Manager Hybrid Cloud Console to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access Quay.io to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.



IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

18.3.4. Requirements for a cluster with user-provisioned infrastructure

For a cluster that contains user-provisioned infrastructure, you must deploy all of the required machines.

This section describes the requirements for deploying OpenShift Container Platform on user-provisioned infrastructure.

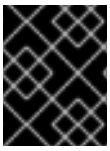
18.3.4.1. Required machines for cluster installation

The smallest OpenShift Container Platform clusters require the following hosts:

Table 18.19. Minimum required hosts

Hosts	Description
One temporary bootstrap machine	The cluster requires the bootstrap machine to deploy the OpenShift Container Platform cluster on the three control plane machines. You can remove the bootstrap machine after you install the cluster.
Three control plane machines	The control plane machines run the Kubernetes and OpenShift Container Platform services that form the control plane.

Hosts	Description
At least two compute machines, which are also known as worker machines.	The workloads requested by OpenShift Container Platform users run on the compute machines.



IMPORTANT

To maintain high availability of your cluster, use separate physical hosts for these cluster machines.

The bootstrap, control plane, and compute machines must use Red Hat Enterprise Linux CoreOS (RHCOS) as the operating system.

Note that RHCOS is based on Red Hat Enterprise Linux (RHEL) 8 and inherits all of its hardware certifications and requirements. See Red Hat Enterprise Linux technology capabilities and limits .

18.3.4.2. Minimum resource requirements for cluster installation

Each cluster machine must meet the following minimum requirements:

Table 18.20. Minimum resource requirements

Machine	Operating System	vCPU [1]	Virtual RAM	Storage	IOPS [2]
Bootstrap	RHCOS	2	16 GB	100 GB	300
Control plane	RHCOS	2	16 GB	100 GB	300
Compute	RHCOS	2	8 GB	100 GB	300

1. One vCPU is equivalent to one physical core when simultaneous multithreading (SMT), or hyperthreading, is not enabled. When enabled, use the following formula to calculate the corresponding ratio: (threads per core × cores) × sockets = vCPUs.
2. OpenShift Container Platform and Kubernetes are sensitive to disk performance, and faster storage is recommended, particularly for etcd on the control plane nodes. Note that on many cloud platforms, storage size and IOPS scale together, so you might need to over-allocate storage volume to obtain sufficient performance.

If an instance type for your platform meets the minimum requirements for cluster machines, it is supported to use in OpenShift Container Platform.

Additional resources

- Optimizing storage

18.3.4.3. Minimum IBM Power requirements

You can install OpenShift Container Platform version 4.11 on the following IBM hardware:

- IBM Power8, Power9, or Power10 processor-based systems

Hardware requirements

- Six IBM Power bare metal servers or six LPARs across multiple PowerVM servers

Operating system requirements

- One instance of an IBM Power8, Power9, or Power10 processor-based system

On your IBM Power instance, set up:

- Three guest virtual machines for OpenShift Container Platform control plane machines
- Two guest virtual machines for OpenShift Container Platform compute machines
- One guest virtual machine for the temporary OpenShift Container Platform bootstrap machine

Disk storage for the IBM Power guest virtual machines

- Local storage, or storage provisioned by the Virtual I/O Server using vSCSI, NPIV (N-Port ID Virtualization) or SSP (shared storage pools)

Network for the PowerVM guest virtual machines

- Dedicated physical adapter, or SR-IOV virtual function
- Available by the Virtual I/O Server using Shared Ethernet Adapter
- Virtualized by the Virtual I/O Server using IBM vNIC

Storage / main memory

- 100 GB / 16 GB for OpenShift Container Platform control plane machines
- 100 GB / 8 GB for OpenShift Container Platform compute machines
- 100 GB / 16 GB for the temporary OpenShift Container Platform bootstrap machine

18.3.4.4. Recommended IBM Power system requirements

Hardware requirements

- Six IBM Power bare metal servers or six LPARs across multiple PowerVM servers

Operating system requirements

- One instance of an IBM Power8, Power9, or Power10 processor-based system

On your IBM Power instance, set up:

- Three guest virtual machines for OpenShift Container Platform control plane machines
- Two guest virtual machines for OpenShift Container Platform compute machines
- One guest virtual machine for the temporary OpenShift Container Platform bootstrap machine

Disk storage for the IBM Power guest virtual machines

- Local storage, or storage provisioned by the Virtual I/O Server using vSCSI, NPIV (N-Port ID Virtualization) or SSP (shared storage pools)

Network for the PowerVM guest virtual machines

- Dedicated physical adapter, or SR-IOV virtual function
- Available by the Virtual I/O Server using Shared Ethernet Adapter
- Virtualized by the Virtual I/O Server using IBM vNIC

Storage / main memory

- 120 GB / 32 GB for OpenShift Container Platform control plane machines
- 120 GB / 32 GB for OpenShift Container Platform compute machines
- 120 GB / 16 GB for the temporary OpenShift Container Platform bootstrap machine

18.3.4.5. Certificate signing requests management

Because your cluster has limited access to automatic machine management when you use infrastructure that you provision, you must provide a mechanism for approving cluster certificate signing requests (CSRs) after installation. The **kube-controller-manager** only approves the kubelet client CSRs. The **machine-approver** cannot guarantee the validity of a serving certificate that is requested by using kubelet credentials because it cannot confirm that the correct machine issued the request. You must determine and implement a method of verifying the validity of the kubelet serving certificate requests and approving them.

18.3.4.6. Networking requirements for user-provisioned infrastructure

All the Red Hat Enterprise Linux CoreOS (RHCOS) machines require networking to be configured in **initramfs** during boot to fetch their Ignition config files.

During the initial boot, the machines require an IP address configuration that is set either through a DHCP server or statically by providing the required boot options. After a network connection is established, the machines download their Ignition config files from an HTTP or HTTPS server. The Ignition config files are then used to set the exact state of each machine. The Machine Config Operator completes more changes to the machines, such as the application of new certificates or keys, after installation.

It is recommended to use a DHCP server for long-term management of the cluster machines. Ensure that the DHCP server is configured to provide persistent IP addresses, DNS server information, and hostnames to the cluster machines.

NOTE

If a DHCP service is not available for your user-provisioned infrastructure, you can instead provide the IP networking configuration and the address of the DNS server to the nodes at RHCOS install time. These can be passed as boot arguments if you are installing from an ISO image. See the *Installing RHCOS and starting the OpenShift Container Platform bootstrap process* section for more information about static IP provisioning and advanced networking options.

The Kubernetes API server must be able to resolve the node names of the cluster machines. If the API servers and worker nodes are in different zones, you can configure a default DNS search zone to allow

the API server to resolve the node names. Another supported approach is to always refer to hosts by their fully-qualified domain names in both the node objects and all DNS requests.

18.3.4.6.1. Setting the cluster node hostnames through DHCP

On Red Hat Enterprise Linux CoreOS (RHCOS) machines, the hostname is set through NetworkManager. By default, the machines obtain their hostname through DHCP. If the hostname is not provided by DHCP, set statically through kernel arguments, or another method, it is obtained through a reverse DNS lookup. Reverse DNS lookup occurs after the network has been initialized on a node and can take time to resolve. Other system services can start prior to this and detect the hostname as **localhost** or similar. You can avoid this by using DHCP to provide the hostname for each cluster node.

Additionally, setting the hostnames through DHCP can bypass any manual DNS record name configuration errors in environments that have a DNS split-horizon implementation.

18.3.4.6.2. Network connectivity requirements

You must configure the network connectivity between machines to allow OpenShift Container Platform cluster components to communicate. Each machine must be able to resolve the hostnames of all other machines in the cluster.

This section provides details about the ports that are required.

Table 18.21. Ports used for all-machine to all-machine communications

Protocol	Port	Description
ICMP	N/A	Network reachability tests
TCP	**1936**	Metrics
	9000-**9999**	Host level services, including the node exporter on ports **9100**-**9101** and the Cluster Version Operator on port**9099**.
	10250-**10259**	The default ports that Kubernetes reserves
	10256	openshift-sdn
UDP	**4789**	VXLAN
	6081	Geneve
	9000-**9999**	Host level services, including the node exporter on ports **9100**-**9101**.
	500	IPsec IKE packets
	4500	IPsec NAT-T packets
TCP/UDP	**30000**-**32767**	Kubernetes node port

Protocol	Port	Description
ESP	N/A	IPsec Encapsulating Security Payload (ESP)

Table 18.22. Ports used for all-machine to control plane communications

Protocol	Port	Description
TCP	**6443**	Kubernetes API

Table 18.23. Ports used for control plane machine to control plane machine communications

Protocol	Port	Description
TCP	**2379-2380**	etcd server and peer ports

NTP configuration for user-provisioned infrastructure
OpenShift Container Platform clusters are configured to use a public Network Time Protocol (NTP) server by default. If you want to use a local enterprise NTP server, or if your cluster is being deployed in a disconnected network, you can configure the cluster to use a specific time server. For more information, see the documentation for *Configuring chrony time service* .

If a DHCP server provides NTP server information, the chrony time service on the Red Hat Enterprise Linux CoreOS (RHCOS) machines read the information and can sync the clock with the NTP servers.

Additional resources

- Configuring chrony time service

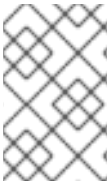
18.3.4.7. User-provisioned DNS requirements

In OpenShift Container Platform deployments, DNS name resolution is required for the following components:

- The Kubernetes API
- The OpenShift Container Platform application wildcard
- The bootstrap, control plane, and compute machines

Reverse DNS resolution is also required for the Kubernetes API, the bootstrap machine, the control plane machines, and the compute machines.

DNS A/AAAA or CNAME records are used for name resolution and PTR records are used for reverse name resolution. The reverse records are important because Red Hat Enterprise Linux CoreOS (RHCOS) uses the reverse records to set the hostnames for all the nodes, unless the hostnames are provided by DHCP. Additionally, the reverse records are used to generate the certificate signing requests (CSR) that OpenShift Container Platform needs to operate.



NOTE

It is recommended to use a DHCP server to provide the hostnames to each cluster node. See the *DHCP recommendations for user-provisioned infrastructure* section for more information.

The following DNS records are required for a user-provisioned OpenShift Container Platform cluster and they must be in place before installation. In each record, **<cluster_name>** is the cluster name and **<base_domain>** is the base domain that you specify in the **install-config.yaml** file. A complete DNS record takes the form: **<component>.<cluster_name>.<base_domain>.**.

Table 18.24. Required DNS records

Component	Record	Description
Kubernetes API	**api.<cluster_name>.<base_domain>.**	A DNS A/AAAA or CNAME record, and a DNS PTR record, to identify the API load balancer. These records must be resolvable by both clients external to the cluster and from all the nodes within the cluster.
	api-int.<cluster_name>.<base_domain>.	A DNS A/AAAA or CNAME record, and a DNS PTR record, to internally identify the API load balancer. These records must be resolvable from all the nodes within the cluster.  IMPORTANT The API server must be able to resolve the worker nodes by the hostnames that are recorded in Kubernetes. If the API server cannot resolve the node names, then proxied API calls can fail, and you cannot retrieve logs from pods.
Routes	***.apps.<cluster_name>.<base_domain>.**	A wildcard DNS A/AAAA or CNAME record that refers to the application ingress load balancer. The application ingress load balancer targets the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default. These records must be resolvable by both clients external to the cluster and from all the nodes within the cluster. For example, **console-openshift-console.apps.<cluster_name>.<base_domain>** is used as a wildcard route to the OpenShift Container Platform console.
Bootstrap machine	**bootstrap.<cluster_name>.<base_domain>.**	A DNS A/AAAA or CNAME record, and a DNS PTR record, to identify the bootstrap machine. These records must be resolvable by the nodes within the cluster.

Component	Record	Description
Control plane machines	**<master><n>.<cluster_name>.<base_domain>.**	DNS A/AAAA or CNAME records and DNS PTR records to identify each machine for the control plane nodes. These records must be resolvable by the nodes within the cluster.
Compute machines	**<worker><n>.<cluster_name>.<base_domain>.**	DNS A/AAAA or CNAME records and DNS PTR records to identify each machine for the worker nodes. These records must be resolvable by the nodes within the cluster.

NOTE

In OpenShift Container Platform 4.4 and later, you do not need to specify etcd host and SRV records in your DNS configuration.

TIP

You can use the **dig** command to verify name and reverse name resolution. See the section on *Validating DNS resolution for user-provisioned infrastructure* for detailed validation steps.

18.3.4.7.1. Example DNS configuration for user-provisioned clusters

This section provides A and PTR record configuration samples that meet the DNS requirements for deploying OpenShift Container Platform on user-provisioned infrastructure. The samples are not meant to provide advice for choosing one DNS solution over another.

In the examples, the cluster name is **ocp4** and the base domain is **example.com**.

Example DNS A record configuration for a user-provisioned cluster

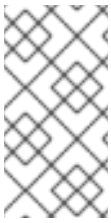
The following example is a BIND zone file that shows sample A records for name resolution in a user-provisioned cluster.

Example 18.4. Sample DNS zone database

```
$TTL 1W
@ IN SOA ns1.example.com. root (
   2019070700 ; serial
   3H  ; refresh (3 hours)
   30M  ; retry (30 minutes)
   2W  ; expiry (2 weeks)
   1W )  ; minimum (1 week)
 IN NS ns1.example.com.
 IN MX 10 smtp.example.com.
;
;
ns1.example.com.  IN A 192.168.1.5
smtp.example.com.  IN A 192.168.1.5
;
helper.example.com.  IN A 192.168.1.5
```

```
helper.ocp4.example.com. IN A 192.168.1.5
;
api.ocp4.example.com.  IN A 192.168.1.5 1
api-int.ocp4.example.com. IN A 192.168.1.5 2
;
*.apps.ocp4.example.com. IN A 192.168.1.5 3
;
bootstrap.ocp4.example.com. IN A 192.168.1.96 4
;
master0.ocp4.example.com. IN A 192.168.1.97 5
master1.ocp4.example.com. IN A 192.168.1.98 6
master2.ocp4.example.com. IN A 192.168.1.99 7
;
worker0.ocp4.example.com. IN A 192.168.1.11 8
worker1.ocp4.example.com. IN A 192.168.1.7 9
;
;EOF
```

1. Provides name resolution for the Kubernetes API. The record refers to the IP address of the API load balancer.
2. Provides name resolution for the Kubernetes API. The record refers to the IP address of the API load balancer and is used for internal cluster communications.
3. Provides name resolution for the wildcard routes. The record refers to the IP address of the application ingress load balancer. The application ingress load balancer targets the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.

   NOTE

   In the example, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

4. Provides name resolution for the bootstrap machine.

5 6 7 Provides name resolution for the control plane machines.

8 9 Provides name resolution for the compute machines.

Example DNS PTR record configuration for a user-provisioned cluster

The following example BIND zone file shows sample PTR records for reverse name resolution in a user-provisioned cluster.

Example 18.5. Sample DNS zone database for reverse records

```
$TTL 1W
@ IN SOA ns1.example.com. root (
  2019070700 ; serial
```

```
    3H  ; refresh (3 hours)
    30M  ; retry (30 minutes)
    2W  ; expiry (2 weeks)
    1W )  ; minimum (1 week)
 IN NS ns1.example.com.
;
5.1.168.192.in-addr.arpa. IN PTR api.ocp4.example.com. 1
5.1.168.192.in-addr.arpa. IN PTR api-int.ocp4.example.com. 2
;
96.1.168.192.in-addr.arpa. IN PTR bootstrap.ocp4.example.com. 3
;
97.1.168.192.in-addr.arpa. IN PTR master0.ocp4.example.com. 4
98.1.168.192.in-addr.arpa. IN PTR master1.ocp4.example.com. 5
99.1.168.192.in-addr.arpa. IN PTR master2.ocp4.example.com. 6
;
11.1.168.192.in-addr.arpa. IN PTR worker0.ocp4.example.com. 7
7.1.168.192.in-addr.arpa. IN PTR worker1.ocp4.example.com. 8
;
;EOF
```

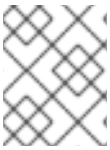
1. Provides reverse DNS resolution for the Kubernetes API. The PTR record refers to the record name of the API load balancer.
2. Provides reverse DNS resolution for the Kubernetes API. The PTR record refers to the record name of the API load balancer and is used for internal cluster communications.
3. Provides reverse DNS resolution for the bootstrap machine.
4. 5. 6. Provides reverse DNS resolution for the control plane machines.
7. 8. Provides reverse DNS resolution for the compute machines.

NOTE

A PTR record is not required for the OpenShift Container Platform application wildcard.

18.3.4.8. Load balancing requirements for user-provisioned infrastructure

Before you install OpenShift Container Platform, you must provision the API and application ingress load balancing infrastructure. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.



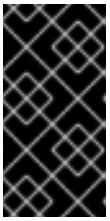
NOTE

If you want to deploy the API and application Ingress load balancers with a Red Hat Enterprise Linux (RHEL) instance, you must purchase the RHEL subscription separately.

The load balancing infrastructure must meet the following requirements:

1. **API load balancer**: Provides a common endpoint for users, both human and machine, to interact with and configure the platform. Configure the following conditions:

- Layer 4 load balancing only. This can be referred to as Raw TCP, SSL Passthrough, or SSL Bridge mode. If you use SSL Bridge mode, you must enable Server Name Indication (SNI) for the API routes.
- A stateless load balancing algorithm. The options vary based on the load balancer implementation.



IMPORTANT

Do not configure session persistence for an API load balancer. Configuring session persistence for a Kubernetes API server might cause performance issues from excess application traffic for your OpenShift Container Platform cluster and the Kubernetes API that runs inside the cluster.

Configure the following ports on both the front and back of the load balancers:

Table 18.25. API load balancer

Port	Back-end machines (pool members)	Internal	External	Description
6443	Bootstrap and control plane. You remove the bootstrap machine from the load balancer after the bootstrap machine initializes the cluster control plane. You must configure the **/readyz** endpoint for the API server health check probe.	X	X	Kubernetes API server
22623	Bootstrap and control plane. You remove the bootstrap machine from the load balancer after the bootstrap machine initializes the cluster control plane.	X		Machine config server

NOTE

The load balancer must be configured to take a maximum of 30 seconds from the time the API server turns off the **/readyz** endpoint to the removal of the API server instance from the pool. Within the time frame after **/readyz** returns an error or becomes healthy, the endpoint must have been removed or added. Probing every 5 or 10 seconds, with two successful requests to become healthy and three to become unhealthy, are well-tested values.

2. **Application Ingress load balancer**: Provides an ingress point for application traffic flowing in from outside the cluster. A working configuration for the Ingress router is required for an OpenShift Container Platform cluster.
   Configure the following conditions:

   - Layer 4 load balancing only. This can be referred to as Raw TCP, SSL Passthrough, or SSL Bridge mode. If you use SSL Bridge mode, you must enable Server Name Indication (SNI) for the ingress routes.

- A connection-based or session-based persistence is recommended, based on the options available and types of applications that will be hosted on the platform.

TIP

If the true IP address of the client can be seen by the application Ingress load balancer, enabling source IP-based session persistence can improve performance for applications that use end-to-end TLS encryption.

Configure the following ports on both the front and back of the load balancers:

Table 18.26. Application Ingress load balancer

Port	Back-end machines (pool members)	Internal	External	Description
443	The machines that run the Ingress Controller pods, compute, or worker, by default.	X	X	HTTPS traffic
80	The machines that run the Ingress Controller pods, compute, or worker, by default.	X	X	HTTP traffic

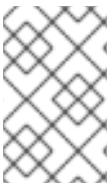
NOTE

If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application Ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes.

18.3.4.8.1. Example load balancer configuration for user-provisioned clusters

This section provides an example API and application ingress load balancer configuration that meets the load balancing requirements for user-provisioned clusters. The sample is an **/etc/haproxy/haproxy.cfg** configuration for an HAProxy load balancer. The example is not meant to provide advice for choosing one load balancing solution over another.

In the example, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.



NOTE

If you are using HAProxy as a load balancer and SELinux is set to **enforcing**, you must ensure that the HAProxy service can bind to the configured TCP port by running **setsebool -P haproxy_connect_any=1**.

Example 18.6. Sample API and application Ingress load balancer configuration

```
global
  log         127.0.0.1 local2
  pidfile     /var/run/haproxy.pid
```

```
    maxconn     4000
    daemon
  defaults
    mode                    http
    log                     global
    option                  dontlognull
    option http-server-close
    option                  redispatch
    retries                 3
    timeout http-request    10s
    timeout queue           1m
    timeout connect         10s
    timeout client          1m
    timeout server          1m
    timeout http-keep-alive 10s
    timeout check           10s
    maxconn                 3000
  listen api-server-6443 (1)
    bind *:6443
    mode tcp
    server bootstrap bootstrap.ocp4.example.com:6443 check inter 1s backup (2)
    server master0 master0.ocp4.example.com:6443 check inter 1s
    server master1 master1.ocp4.example.com:6443 check inter 1s
    server master2 master2.ocp4.example.com:6443 check inter 1s
  listen machine-config-server-22623 (3)
    bind *:22623
    mode tcp
    option  httpchk GET /readyz HTTP/1.0
    option  log-health-checks
    balance roundrobin
    server bootstrap bootstrap.ocp4.example.com:6443 verify none check check-ssl inter 10s fall 2
  rise 3 backup (4)
    server master0 master0.ocp4.example.com:6443 weight 1 verify none check check-ssl inter 10s
  fall 2 rise 3
    server master1 master1.ocp4.example.com:6443 weight 1 verify none check check-ssl inter 10s
  fall 2 rise 3
    server master2 master2.ocp4.example.com:6443 weight 1 verify none check check-ssl inter 10s
  fall 2 rise 3
  listen ingress-router-443 (5)
    bind *:443
    mode tcp
    balance source
    server worker0 worker0.ocp4.example.com:443 check inter 1s
    server worker1 worker1.ocp4.example.com:443 check inter 1s
  listen ingress-router-80 (6)
    bind *:80
    mode tcp
    balance source
    server worker0 worker0.ocp4.example.com:80 check inter 1s
    server worker1 worker1.ocp4.example.com:80 check inter 1s
```

(1) Port **6443** handles the Kubernetes API traffic and points to the control plane machines.

(2) (4) The bootstrap entries must be in place before the OpenShift Container Platform cluster installation and they must be removed after the bootstrap process is complete.

3 Port **22623** handles the machine config server traffic and points to the control plane machines.

5 Port **443** handles the HTTPS traffic and points to the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.

6 Port **80** handles the HTTP traffic and points to the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.

NOTE

If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application Ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes.

TIP

If you are using HAProxy as a load balancer, you can check that the **haproxy** process is listening on ports **6443**, **22623**, **443**, and **80** by running **netstat -nltupe** on the HAProxy node.

18.3.5. Preparing the user-provisioned infrastructure

Before you install OpenShift Container Platform on user-provisioned infrastructure, you must prepare the underlying infrastructure.

This section provides details about the high-level steps required to set up your cluster infrastructure in preparation for an OpenShift Container Platform installation. This includes configuring IP networking and network connectivity for your cluster nodes, enabling the required ports through your firewall, and setting up the required DNS and load balancing infrastructure.

After preparation, your cluster infrastructure must meet the requirements outlined in the *Requirements for a cluster with user-provisioned infrastructure* section.

Prerequisites

- You have reviewed the OpenShift Container Platform 4.x Tested Integrations page.
- You have reviewed the infrastructure requirements detailed in the *Requirements for a cluster with user-provisioned infrastructure* section.

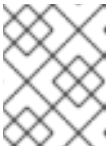
Procedure

1. If you are using DHCP to provide the IP networking configuration to your cluster nodes, configure your DHCP service.
   a. Add persistent IP addresses for the nodes to your DHCP server configuration. In your configuration, match the MAC address of the relevant network interface to the intended IP address for each node.
   b. When you use DHCP to configure IP addressing for the cluster machines, the machines also obtain the DNS server information through DHCP. Define the persistent DNS server address that is used by the cluster nodes through your DHCP server configuration.

NOTE

If you are not using a DHCP service, you must provide the IP networking configuration and the address of the DNS server to the nodes at RHCOS install time. These can be passed as boot arguments if you are installing from an ISO image. See the *Installing RHCOS and starting the OpenShift Container Platform bootstrap process* section for more information about static IP provisioning and advanced networking options.

c. Define the hostnames of your cluster nodes in your DHCP server configuration. See the *Setting the cluster node hostnames through DHCP* section for details about hostname considerations.

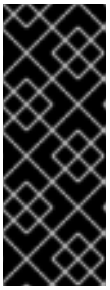


NOTE

If you are not using a DHCP service, the cluster nodes obtain their hostname through a reverse DNS lookup.

2. Ensure that your network infrastructure provides the required network connectivity between the cluster components. See the *Networking requirements for user-provisioned infrastructure* section for details about the requirements.

3. Configure your firewall to enable the ports required for the OpenShift Container Platform cluster components to communicate. See *Networking requirements for user-provisioned infrastructure* section for details about the ports that are required.



IMPORTANT

By default, port **1936** is accessible for an OpenShift Container Platform cluster, because each control plane node needs access to this port.

Avoid using the Ingress load balancer to expose this port, because doing so might result in the exposure of sensitive information, such as statistics and metrics, related to Ingress Controllers.

4. Setup the required DNS infrastructure for your cluster.

   a. Configure DNS name resolution for the Kubernetes API, the application wildcard, the bootstrap machine, the control plane machines, and the compute machines.

   b. Configure reverse DNS resolution for the Kubernetes API, the bootstrap machine, the control plane machines, and the compute machines.
   See the *User-provisioned DNS requirements* section for more information about the OpenShift Container Platform DNS requirements.

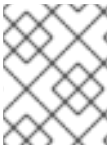
5. Validate your DNS configuration.

   a. From your installation node, run DNS lookups against the record names of the Kubernetes API, the wildcard routes, and the cluster nodes. Validate that the IP addresses in the responses correspond to the correct components.

   b. From your installation node, run reverse DNS lookups against the IP addresses of the load balancer and the cluster nodes. Validate that the record names in the responses correspond to the correct components.

See the *Validating DNS resolution for user-provisioned infrastructure* section for detailed DNS validation steps.

6. Provision the required API and application ingress load balancing infrastructure. See the *Load balancing requirements for user-provisioned infrastructure* section for more information about the requirements.



NOTE

Some load balancing solutions require the DNS name resolution for the cluster nodes to be in place before the load balancing is initialized.

18.3.6. Validating DNS resolution for user-provisioned infrastructure

You can validate your DNS configuration before installing OpenShift Container Platform on user-provisioned infrastructure.

IMPORTANT

The validation steps detailed in this section must succeed before you install your cluster.

Prerequisites

- You have configured the required DNS records for your user-provisioned infrastructure.

Procedure

1. From your installation node, run DNS lookups against the record names of the Kubernetes API, the wildcard routes, and the cluster nodes. Validate that the IP addresses contained in the responses correspond to the correct components.

   a. Perform a lookup against the Kubernetes API record name. Check that the result points to the IP address of the API load balancer:

   ```
   $ dig +noall +answer @<nameserver_ip> api.<cluster_name>.<base_domain>
   ```
   (1)

   (1) Replace **<nameserver_ip>** with the IP address of the nameserver, **<cluster_name>** with your cluster name, and **<base_domain>** with your base domain name.

   Example output

   ```
   api.ocp4.example.com.  604800 IN A 192.168.1.5
   ```

   b. Perform a lookup against the Kubernetes internal API record name. Check that the result points to the IP address of the API load balancer:

   ```
   $ dig +noall +answer @<nameserver_ip> api-int.<cluster_name>.<base_domain>
   ```

   Example output

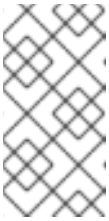
   ```
   api-int.ocp4.example.com.  604800 IN A 192.168.1.5
   ```

c. Test an example ***.apps.<cluster_name>.<base_domain>*** DNS wildcard lookup. All of the application wildcard lookups must resolve to the IP address of the application ingress load balancer:

```
$ dig +noall +answer @<nameserver_ip> random.apps.<cluster_name>.<base_domain>
```

Example output

```
random.apps.ocp4.example.com.  604800 IN A 192.168.1.5
```



NOTE

In the example outputs, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

You can replace **random** with another wildcard value. For example, you can query the route to the OpenShift Container Platform console:

```
$ dig +noall +answer @<nameserver_ip> console-openshift-console.apps.
<cluster_name>.<base_domain>
```

Example output

```
console-openshift-console.apps.ocp4.example.com. 604800 IN A 192.168.1.5
```

d. Run a lookup against the bootstrap DNS record name. Check that the result points to the IP address of the bootstrap node:

```
$ dig +noall +answer @<nameserver_ip> bootstrap.<cluster_name>.<base_domain>
```

Example output

```
bootstrap.ocp4.example.com.  604800 IN A 192.168.1.96
```

e. Use this method to perform lookups against the DNS record names for the control plane and compute nodes. Check that the results correspond to the IP addresses of each node.

2. From your installation node, run reverse DNS lookups against the IP addresses of the load balancer and the cluster nodes. Validate that the record names contained in the responses correspond to the correct components.

a. Perform a reverse lookup against the IP address of the API load balancer. Check that the response includes the record names for the Kubernetes API and the Kubernetes internal API:

```
$ dig +noall +answer @<nameserver_ip> -x 192.168.1.5
```

Example output

```
5.1.168.192.in-addr.arpa. 604800 IN PTR api-int.ocp4.example.com. 1
5.1.168.192.in-addr.arpa. 604800 IN PTR api.ocp4.example.com. 2
```

1 Provides the record name for the Kubernetes internal API.

2 Provides the record name for the Kubernetes API.

NOTE

A PTR record is not required for the OpenShift Container Platform application wildcard. No validation step is needed for reverse DNS resolution against the IP address of the application ingress load balancer.

b. Perform a reverse lookup against the IP address of the bootstrap node. Check that the result points to the DNS record name of the bootstrap node:

```
$ dig +noall +answer @<nameserver_ip> -x 192.168.1.96
```

Example output

```
96.1.168.192.in-addr.arpa. 604800 IN PTR bootstrap.ocp4.example.com.
```

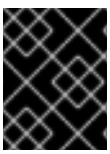
c. Use this method to perform reverse lookups against the IP addresses for the control plane and compute nodes. Check that the results correspond to the DNS record names of each node.

18.3.7. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the **~/.ssh/authorized_keys** list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The **./openshift-install gather** command also requires the SSH public key to be in place on the cluster nodes.



IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.

NOTE

You must use a local key, not one that you configured with platform-specific approaches such as AWS key pairs.

Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N '' -f <path>/<file_name> 1
```

1 Specify the path and file name, such as ~/**.ssh/id_ed25519**, of the new SSH key. If you have an existing key pair, ensure your public key is in the your ~/**.ssh** directory.

NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS validated or Modules In Process cryptographic libraries on the **x86_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the ~/**.ssh/id_ed25519.pub** public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the **./openshift-install gather** command.

NOTE

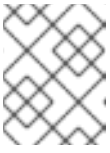
On some distributions, default SSH private key identities such as ~/**.ssh/id_rsa** and ~/**.ssh/id_dsa** are managed automatically.

a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

Example output

```
Agent pid 31874
```



NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

1 Specify the path and file name for your SSH private key, such as **~/.ssh/id_ed25519**

Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

18.3.8. Manually creating the installation configuration file

Prerequisites

- You have an SSH public key on your local machine to provide to the installation program. The key will be used for SSH authentication onto your cluster nodes for debugging and disaster recovery.
- You have obtained the OpenShift Container Platform installation program and the pull secret for your cluster.

Procedure

1. Create an installation directory to store your required installation assets in:

```
$ mkdir <installation_directory>
```

IMPORTANT

You must create a directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

2. Customize the sample **install-config.yaml** file template that is provided and save it in the **<installation_directory>**.

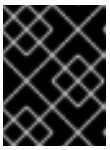
NOTE

You must name this configuration file **install-config.yaml**.

NOTE

For some platform types, you can alternatively run **./openshift-install create install-config --dir <installation_directory>** to generate an **install-config.yaml** file. You can provide details about your cluster configuration at the prompts.

3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.



IMPORTANT

The **install-config.yaml** file is consumed during the next step of the installation process. You must back it up now.

18.3.8.1. Installation configuration parameters

Before you deploy an OpenShift Container Platform cluster, you provide a customized **install-config.yaml** installation configuration file that describes the details for your environment.

NOTE

After installation, you cannot modify these parameters in the **install-config.yaml** file.

18.3.8.1.1. Required configuration parameters

Required installation configuration parameters are described in the following table:

Table 18.27. Required parameters

Parameter	Description	Values
apiVersion	The API version for the **install-config.yaml** content. The current version is **v1**. The installer may also support older API versions.	String
baseDomain	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the **baseDomain** and **metadata.name** parameter values that uses the **<metadata.name>.<baseDomain>** format.	A fully-qualified domain or subdomain name, such as **example.com**.
metadata	Kubernetes resource **ObjectMeta**, from which only the **name** parameter is consumed.	Object

Parameter	Description	Values
metadata.name	The name of the cluster. DNS records for the cluster are all subdomains of **{{.metadata.name}}.{{.baseDomain}}**.	String of lowercase letters, hyphens (**-**), and periods (**.**), such as **dev**.
platform	The configuration for the specific platform upon which to perform the installation: **alibabacloud**, **aws**, **baremetal**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**. For additional information about **platform.<platform>** parameters, consult the table for your specific platform that follows.	Object
pullSecret	Get a pull secret from the Red Hat OpenShift Cluster Manager to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	{ "auths":{ "cloud.openshift.com":{ "auth":"b3Blb=", "email":"you@example.com" }, "quay.io":{ "auth":"b3Blb=", "email":"you@example.com" } } }

18.3.8.1.2. Network configuration parameters

You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

- If you use the OVN-Kubernetes cluster network provider, both IPv4 and IPv6 address families are supported.
- If you use the OpenShift SDN cluster network provider, only the IPv4 address family is supported.

If you configure your cluster to use both IP address families, review the following requirements:

- Both IP families must use the same network interface for the default gateway.

- Both IP families must have the default gateway.
- You must specify IPv4 and IPv6 addresses in the same order for all network configuration parameters. For example, in the following configuration IPv4 addresses are listed before IPv6 addresses.

```
networking:
  clusterNetwork:
  - cidr: 10.128.0.0/14
    hostPrefix: 23
  - cidr: fd00:10:128::/56
    hostPrefix: 64
  serviceNetwork:
  - 172.30.0.0/16
  - fd00:172:16::/112
```

NOTE

Globalnet is not supported with Red Hat OpenShift Data Foundation disaster recovery solutions. For regional disaster recovery scenarios, ensure that you use a nonoverlapping range of private IP addresses for the cluster and service networks in each cluster.

Table 18.28. Network parameters

Parameter	Description	Values
networking	The configuration for the cluster network.	Object  **NOTE** You cannot modify parameters specified by the **networking** object after installation.
networking.networkType	The cluster network provider Container Network Interface (CNI) cluster network provider to install.	Either **OpenShiftSDN** or **OVNKubernetes**. **OpenShiftSDN** is a CNI provider for all-Linux networks. **OVNKubernetes** is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is **OpenShiftSDN**.
networking.clusterNetwork	The IP address blocks for pods. The default value is **10.128.0.0/14** with a host prefix of **/23**. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: `networking:` `  clusterNetwork:` `  - cidr: 10.128.0.0/14` `    hostPrefix: 23`

Parameter	Description	Values
networking.clusterNetwork.cidr	Required if you use **networking.clusterNetwork**. An IP address block. An IPv4 network.	An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between **0** and **32**.
networking.clusterNetwork.hostPrefix	The subnet prefix length to assign to each individual node. For example, if **hostPrefix** is set to **23** then each node is assigned a /**23** subnet out of the given **cidr**. A **hostPrefix** value of **23** provides 510 (2^(32 - 23) - 2) pod IP addresses.	A subnet prefix. The default value is **23**.
networking.serviceNetwork	The IP address block for services. The default value is **172.30.0.0/16**. The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.	An array with an IP address block in CIDR format. For example: `networking:` `  serviceNetwork:` `  - 172.30.0.0/16`
networking.machineNetwork	The IP address blocks for machines. If you specify multiple IP address blocks, the blocks must not overlap. If you specify multiple IP kernel arguments, the **machineNetwork.cidr** value must be the CIDR of the primary network.	An array of objects. For example: `networking:` `  machineNetwork:` `  - cidr: 10.0.0.0/16`
networking.machineNetwork.cidr	Required if you use **networking.machineNetwork**. An IP address block. The default value is **10.0.0.0/16** for all platforms other than libvirt. For libvirt, the default value is **192.168.126.0/24**.	An IP network block in CIDR notation. For example, **10.0.0.0/16**. **NOTE** Set the **networking.machineNetwork** to match the CIDR that the preferred NIC resides in.

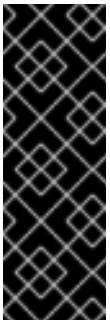
18.3.8.1.3. Optional configuration parameters

Optional installation configuration parameters are described in the following table:

Table 18.29. Optional parameters

Parameter	Description	Values
additionalTrustBundle	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String
capabilities	Controls the installation of optional core cluster components. You can reduce the footprint of your OpenShift Container Platform cluster by disabling optional components.	String array
capabilities.baselineCapabilitySet	Selects an initial set of optional capabilities to enable. Valid values are **None**, **v4.11** and **vCurrent**. **v4.11** enables the **baremetal** Operator, the **marketplace** Operator, and the **openshift-samples** content. **vCurrent** installs the recommended set of capabilities for the current version of OpenShift Container Platform. The default value is **vCurrent**.	String
capabilities.additionalEnabledCapabilities	Extends the set of optional capabilities beyond what you specify in **baselineCapabilitySet**. Valid values are **baremetal**, **marketplace** and **openshift-samples**. You may specify multiple capabilities in this parameter.	String array
cgroupsV2	Enables Linux control groups version 2 (cgroups v2) on specific nodes in your cluster. The OpenShift Container Platform process for enabling cgroups v2 disables all cgroup version 1 controllers and hierarchies. The OpenShift Container Platform cgroups version 2 feature is in Developer Preview and is not supported by Red Hat at this time.	**true**
compute	The configuration for the machines that comprise the compute nodes.	Array of **MachinePool** objects.

Parameter	Description	Values
compute.architecture	Determines the instruction set architecture of the machines in the pool. Currently, heteregeneous clusters are not supported, so all pools must specify the same architecture. Valid values are **ppc64le** (the default).	String
compute.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  IMPORTANT If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
compute.name	Required if you use **compute**. The name of the machine pool.	**worker**
compute.platform	Required if you use **compute**. Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the **controlPlane.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
compute.replicas	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to **2**. The default value is **3**.
controlPlane	The configuration for the machines that comprise the control plane.	Array of **MachinePool** objects.

Parameter	Description	Values
controlPlane.architecture	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are **ppc64le** (the default).	String
controlPlane.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  IMPORTANT If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
controlPlane.name	Required if you use **controlPlane**. The name of the machine pool.	**master**
controlPlane.platform	Required if you use **controlPlane**. Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the **compute.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
controlPlane.replicas	The number of control plane machines to provision.	The only supported value is **3**, which is the default value.

Parameter	Description	Values
credentialsMode	The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported.  **NOTE** Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the *Cloud Credential Operator* entry in the *Cluster Operators reference* content.  **NOTE** If your AWS account has service control policies (SCP) enabled, you must configure the **credentialsMode** parameter to **Mint**, **Passthrough** or **Manual**.	**Mint**, **Passthrough**, **Manual** or an empty string (**""**).

Parameter	Description	Values
fips	Enable or disable FIPS mode. The default is **false** (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.  **IMPORTANT** To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.  **NOTE** If you are using Azure File storage, you cannot enable FIPS mode.	**false** or **true**
imageContentSources	Sources and repositories for the release-image content.	Array of objects. Includes a **source** and, optionally, **mirrors**, as described in the following rows of this table.
imageContentSources.source	Required if you use **imageContentSources**. Specify the repository that users refer to, for example, in image pull specifications.	String

Parameter	Description	Values
imageContentSources.mirrors	Specify one or more repositories that may also contain the same images.	Array of strings
publish	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	**Internal** or **External**. The default value is **External**. Setting this field to **Internal** is not supported on non-cloud platforms and IBM Cloud VPC.  **IMPORTANT** If the value of the field is set to **Internal**, the cluster will become non-functional. For more information, refer to BZ#1953035.
sshKey	The SSH key to authenticate access to your cluster machines.  **NOTE** For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.	For example, **sshKey: ssh-ed25519 AAAA..**.

18.3.8.2. Sample install-config.yaml file for IBM Power

You can customize the **install-config.yaml** file to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.

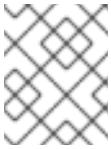
```
apiVersion: v1
baseDomain: example.com (1)
compute: (2)
- hyperthreading: Enabled (3)
  name: worker
  replicas: 0 (4)
  architecture : ppc64le
controlPlane: (5)
  hyperthreading: Enabled (6)
```

```
  name: master
  replicas: 3 7
  architecture : ppc64le
metadata:
  name: test 8
networking:
  clusterNetwork:
  - cidr: 10.128.0.0/14 9
    hostPrefix: 23 10
  networkType: OpenShiftSDN
  serviceNetwork: 11
  - 172.30.0.0/16
platform:
  none: {} 12
fips: false 13
pullSecret: '{"auths":{"<local_registry>": {"auth": "<credentials>","email": "you@example.com"}}}' 14
sshKey: 'ssh-ed25519 AAAA...' 15
additionalTrustBundle: | 16
  -----BEGIN CERTIFICATE-----
  ZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZ
  -----END CERTIFICATE-----
imageContentSources: 17
- mirrors:
  - <local_registry>/<local_repository_name>/release
  source: quay.io/openshift-release-dev/ocp-release
- mirrors:
  - <local_registry>/<local_repository_name>/release
  source: quay.io/openshift-release-dev/ocp-v4.0-art-dev
```

1 The base domain of the cluster. All DNS records must be sub-domains of this base and include the cluster name.

2 5 The **controlPlane** section is a single mapping, but the **compute** section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, **-**, and the first line of the **controlPlane** section must not. Only one control plane pool is used.

3 6 Specifies whether to enable or disable simultaneous multithreading (SMT), or hyperthreading. By default, SMT is enabled to increase the performance of the cores in your machines. You can disable it by setting the parameter value to **Disabled**. If you disable SMT, you must disable it in all cluster machines; this includes both control plane and compute machines.



NOTE

Simultaneous multithreading (SMT) is enabled by default. If SMT is not enabled in your BIOS settings, the **hyperthreading** parameter has no effect.

IMPORTANT

If you disable **hyperthreading**, whether in the BIOS or in the **install-config.yaml** file, ensure that your capacity planning accounts for the dramatically decreased machine performance.

4 You must set this value to **0** when you install OpenShift Container Platform on user-provisioned infrastructure. In installer-provisioned installations, the parameter controls the number of compute

NOTE

If you are installing a three-node cluster, do not deploy any compute machines when you install the Red Hat Enterprise Linux CoreOS (RHCOS) machines.

7 The number of control plane machines that you add to the cluster. Because the cluster uses these values as the number of etcd endpoints in the cluster, the value must match the number of control plane machines that you deploy.

8 The cluster name that you specified in your DNS records.

9 A block of IP addresses from which pod IP addresses are allocated. This block must not overlap with existing physical networks. These IP addresses are used for the pod network. If you need to access the pods from an external network, you must configure load balancers and routers to manage the traffic.

NOTE

Class E CIDR range is reserved for a future use. To use the Class E CIDR range, you must ensure your networking environment accepts the IP addresses within the Class E CIDR range.

10 The subnet prefix length to assign to each individual node. For example, if **hostPrefix** is set to **23**, then each node is assigned a **/23** subnet out of the given **cidr**, which allows for 510 (2^(32 - 23) - 2) pod IP addresses. If you are required to provide access to nodes from an external network, configure load balancers and routers to manage the traffic.

11 The IP address pool to use for service IP addresses. You can enter only one IP address pool. This block must not overlap with existing physical networks. If you need to access the services from an external network, configure load balancers and routers to manage the traffic.

12 You must set the platform to **none**. You cannot provide additional platform configuration variables for IBM Power infrastructure.

IMPORTANT

Clusters that are installed with the platform type **none** are unable to use some features, such as managing compute machines with the Machine API. This limitation applies even if the compute machines that are attached to the cluster are installed on a platform that would normally support the feature. This parameter cannot be changed after installation.

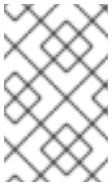
13 Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.

IMPORTANT

To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.

14 For **<local_registry>**, specify the registry domain name, and optionally the port, that your mirror registry uses to serve content. For example, **registry.example.com** or **registry.example.com:5000**. For **<credentials>**, specify the base64-encoded user name and password for your mirror registry.

15 The SSH public key for the **core** user in Red Hat Enterprise Linux CoreOS (RHCOS).



NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

16 Provide the contents of the certificate file that you used for your mirror registry.

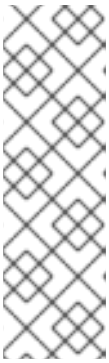
17 Provide the **imageContentSources** section from the output of the command to mirror the repository.

18.3.8.3. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.



NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
```

1. A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
2. A proxy URL to use for creating HTTPS connections outside the cluster.
3. A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use ***** to bypass the proxy for all destinations.
4. If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace that contains one or more additional CA certificates that are required for proxying HTTPS connections. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges these contents with the Red Hat Enterprise Linux CoreOS (RHCOS) trust bundle, and this config map is referenced in the **trustedCA** field of the **Proxy** object. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.

NOTE

The installation program does not support the proxy **readinessEndpoints** field.

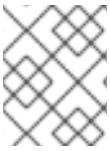
NOTE

If the installer times out, restart and then complete the deployment by using the **wait-for** command of the installer. For example:

```
$ ./openshift-install wait-for install-complete --log-level debug
```

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.



NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

18.3.8.4. Configuring a three-node cluster

Optionally, you can deploy zero compute machines in a bare metal cluster that consists of three control plane machines only. This provides smaller, more resource efficient clusters for cluster administrators and developers to use for testing, development, and production.

In three-node OpenShift Container Platform environments, the three control plane machines are schedulable, which means that your application workloads are scheduled to run on them.

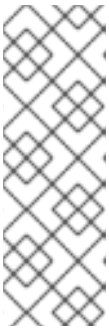
Prerequisites

- You have an existing **install-config.yaml** file.

Procedure

- Ensure that the number of compute replicas is set to **0** in your **install-config.yaml** file, as shown in the following **compute** stanza:

```
compute:
- name: worker
  platform: {}
  replicas: 0
```



NOTE

You must set the value of the **replicas** parameter for the compute machines to **0** when you install OpenShift Container Platform on user-provisioned infrastructure, regardless of the number of compute machines you are deploying. In installer-provisioned installations, the parameter controls the number of compute machines that the cluster creates and manages for you. This does not apply to user-provisioned installations, where the compute machines are deployed manually.

For three-node cluster installations, follow these next steps:

- If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes. See the *Load balancing requirements for user-provisioned infrastructure* section for more information.

- When you create the Kubernetes manifest files in the following procedure, ensure that the **mastersSchedulable** parameter in the **<installation_directory>/manifests/cluster-scheduler-02-config.yml** file is set to **true**. This enables your application workloads to run on the control plane nodes.

- Do not deploy any compute nodes when you create the Red Hat Enterprise Linux CoreOS (RHCOS) machines.

18.3.9. Cluster Network Operator configuration

The configuration for the cluster network is specified as part of the Cluster Network Operator (CNO) configuration and stored in a custom resource (CR) object that is named **cluster**. The CR specifies the fields for the **Network** API in the **operator.openshift.io** API group.

The CNO configuration inherits the following fields during cluster installation from the **Network** API in the **Network.config.openshift.io** API group and these fields cannot be changed:

clusterNetwork

IP address pools from which pod IP addresses are allocated.

serviceNetwork

IP address pool for services.

defaultNetwork.type

Cluster network provider, such as OpenShift SDN or OVN-Kubernetes.

You can specify the cluster network provider configuration for your cluster by setting the fields for the **defaultNetwork** object in the CNO object named **cluster**.

18.3.9.1. Cluster Network Operator configuration object

The fields for the Cluster Network Operator (CNO) are described in the following table:

Table 18.30. Cluster Network Operator configuration object

Field	Type	Description
metadata.name	**string**	The name of the CNO object. This name is always **cluster**.
spec.clusterNetwork	**array**	A list specifying the blocks of IP addresses from which pod IP addresses are allocated and the subnet prefix length assigned to each individual node in the cluster. For example: `spec:` `  clusterNetwork:` `  - cidr: 10.128.0.0/19` `  hostPrefix: 23` `  - cidr: 10.128.32.0/19` `  hostPrefix: 23` You can customize this field only in the **install-config.yaml** file before you create the manifests. The value is read-only in the manifest file.

Field	Type	Description
spec.serviceNetwork	**array**	A block of IP addresses for services. The OpenShift SDN and OVN-Kubernetes Container Network Interface (CNI) network providers support only a single IP address block for the service network. For example: `spec:` `  serviceNetwork:` `  - 172.30.0.0/14` You can customize this field only in the **install-config.yaml** file before you create the manifests. The value is read-only in the manifest file.
spec.defaultNetwork	**object**	Configures the Container Network Interface (CNI) cluster network provider for the cluster network.
spec.kubeProxyConfig	**object**	The fields for this object specify the kube-proxy configuration. If you are using the OVN-Kubernetes cluster network provider, the kube-proxy configuration has no effect.

defaultNetwork object configuration
The values for the **defaultNetwork** object are defined in the following table:

Table 18.31. defaultNetwork object

Field	Type	Description
type	**string**	Either **OpenShiftSDN** or **OVNKubernetes**. The cluster network provider is selected during installation. This value cannot be changed after cluster installation.  **NOTE** OpenShift Container Platform uses the OpenShift SDN Container Network Interface (CNI) cluster network provider by default.
openshiftSDNConfig	**object**	This object is only valid for the OpenShift SDN cluster network provider.
ovnKubernetesConfig	**object**	This object is only valid for the OVN-Kubernetes cluster network provider.

Configuration for the OpenShift SDN CNI cluster network provider
The following table describes the configuration fields for the OpenShift SDN Container Network Interface (CNI) cluster network provider.

Table 18.32. **openshiftSDNConfig** object

Field	Type	Description
mode	**string**	Configures the network isolation mode for OpenShift SDN. The default value is **NetworkPolicy**. The values **Multitenant** and **Subnet** are available for backwards compatibility with OpenShift Container Platform 3.x but are not recommended. This value cannot be changed after cluster installation.
mtu	**integer**	The maximum transmission unit (MTU) for the VXLAN overlay network. This is detected automatically based on the MTU of the primary network interface. You do not normally need to override the detected MTU. If the auto-detected value is not what you expect it to be, confirm that the MTU on the primary network interface on your nodes is correct. You cannot use this option to change the MTU value of the primary network interface on the nodes. If your cluster requires different MTU values for different nodes, you must set this value to **50** less than the lowest MTU value in your cluster. For example, if some nodes in your cluster have an MTU of **9001**, and some have an MTU of**1500**, you must set this value to **1450**. This value cannot be changed after cluster installation.
vxlanPort	**integer**	The port to use for all VXLAN packets. The default value is **4789**. This value cannot be changed after cluster installation. If you are running in a virtualized environment with existing nodes that are part of another VXLAN network, then you might be required to change this. For example, when running an OpenShift SDN overlay on top of VMware NSX-T, you must select an alternate port for the VXLAN, because both SDNs use the same default VXLAN port number. On Amazon Web Services (AWS), you can select an alternate port for the VXLAN between port **9000** and port **9999**.

Example OpenShift SDN configuration

```
defaultNetwork:
  type: OpenShiftSDN
  openshiftSDNConfig:
    mode: NetworkPolicy
    mtu: 1450
    vxlanPort: 4789
```

Configuration for the OVN-Kubernetes CNI cluster network provider

The following table describes the configuration fields for the OVN-Kubernetes CNI cluster network provider.

Table 18.33. **ovnKubernetesConfig** object

Field	Type	Description
mtu	**integer**	The maximum transmission unit (MTU) for the Geneve (Generic Network Virtualization Encapsulation) overlay network. This is detected automatically based on the MTU of the primary network interface. You do not normally need to override the detected MTU. If the auto-detected value is not what you expect it to be, confirm that the MTU on the primary network interface on your nodes is correct. You cannot use this option to change the MTU value of the primary network interface on the nodes. If your cluster requires different MTU values for different nodes, you must set this value to **100** less than the lowest MTU value in your cluster. For example, if some nodes in your cluster have an MTU of **9001**, and some have an MTU of**1500**, you must set this value to **1400**.
genevePort	**integer**	The port to use for all Geneve packets. The default value is **6081**. This value cannot be changed after cluster installation.
ipsecConfig	**object**	Specify an empty object to enable IPsec encryption.
policyAuditConfig	**object**	Specify a configuration object for customizing network policy audit logging. If unset, the defaults audit log settings are used.
gatewayConfig	**object**	Optional: Specify a configuration object for customizing how egress traffic is sent to the node gateway.  NOTE While migrating egress traffic, you can expect some disruption to workloads and service traffic until the Cluster Network Operator (CNO) successfully rolls out the changes.

Table 18.34. **policyAuditConfig** object

Field	Type	Description
rateLimit	integer	The maximum number of messages to generate every second per node. The default value is **20** messages per second.
maxFileSize	integer	The maximum size for the audit log in bytes. The default value is **50000000** or 50 MB.

Field	Type	Description
destination	string	One of the following additional audit log targets: **libc** The libc **syslog()** function of the journald process on the host. **udp:<host>:<port>** A syslog server. Replace **<host>:<port>** with the host and port of the syslog server. **unix:<file>** A Unix Domain Socket file specified by **<file>**. **null** Do not send the audit logs to any additional target.
syslogFacility	string	The syslog facility, such as **kern**, as defined by RFC5424. The default value is **local0**.

Table 18.35. **gatewayConfig** object

Field	Type	Description
routingViaHost	**boolean**	Set this field to **true** to send egress traffic from pods to the host networking stack. For highly-specialized installations and applications that rely on manually configured routes in the kernel routing table, you might want to route egress traffic to the host networking stack. By default, egress traffic is processed in OVN to exit the cluster and is not affected by specialized routes in the kernel routing table. The default value is **false**. This field has an interaction with the Open vSwitch hardware offloading feature. If you set this field to **true**, you do not receive the performance benefits of the offloading because egress traffic is processed by the host networking stack.

Example OVN-Kubernetes configuration with IPSec enabled

```
defaultNetwork:
  type: OVNKubernetes
  ovnKubernetesConfig:
    mtu: 1400
    genevePort: 6081
    ipsecConfig: {}
```

kubeProxyConfig object configuration

The values for the **kubeProxyConfig** object are defined in the following table:

Table 18.36. **kubeProxyConfig** object

Field	Type	Description
iptablesSyncPeriod	**string**	The refresh period for **iptables** rules. The default value is **30s**. Valid suffixes include **s**, **m**, and **h** and are described in the Go **time** package documentation. NOTE Because of performance improvements introduced in OpenShift Container Platform 4.3 and greater, adjusting the **iptablesSyncPeriod** parameter is no longer necessary.
proxyArguments.iptables-min-sync-period	**array**	The minimum duration before refreshing **iptables** rules. This field ensures that the refresh does not happen too frequently. Valid suffixes include **s**, **m**, and **h** and are described in the Go **time** package. The default value is: `kubeProxyConfig:` `  proxyArguments:` `  iptables-min-sync-period:` `  - 0s`

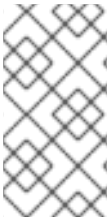
18.3.10. Creating the Kubernetes manifest and Ignition config files

Because you must modify some cluster definition files and manually start the cluster machines, you must generate the Kubernetes manifest and Ignition config files that the cluster needs to configure the machines.

The installation configuration file transforms into the Kubernetes manifests. The manifests wrap into the Ignition configuration files, which are later used to configure the cluster machines.

IMPORTANT

- The Ignition config files that the OpenShift Container Platform installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.



NOTE

The installation program that generates the manifest and Ignition files is architecture specific and can be obtained from the client image mirror. The Linux version of the installation program (without an architecture postfix) runs on ppc64le only. This installer program is also available as a Mac OS version.

Prerequisites

- You obtained the OpenShift Container Platform installation program. For a restricted network installation, these files are on your mirror host.
- You created the **install-config.yaml** installation configuration file.

Procedure

1. Change to the directory that contains the OpenShift Container Platform installation program and generate the Kubernetes manifests for the cluster:

```
$ ./openshift-install create manifests --dir <installation_directory> 1
```

1 For **<installation_directory>**, specify the installation directory that contains the **install-config.yaml** file you created.

WARNING

If you are installing a three-node cluster, skip the following step to allow the control plane nodes to be schedulable.

IMPORTANT

When you configure control plane nodes from the default unschedulable to schedulable, additional subscriptions are required. This is because control plane nodes then become compute nodes.

2. Check that the **mastersSchedulable** parameter in the **<installation_directory>/manifests/cluster-scheduler-02-config.yml** Kubernetes manifest file is set to **false**. This setting prevents pods from being scheduled on the control plane machines:
   a. Open the **<installation_directory>/manifests/cluster-scheduler-02-config.yml** file.
   b. Locate the **mastersSchedulable** parameter and ensure that it is set to **false**.
   c. Save and exit the file.
3. To create the Ignition configuration files, run the following command from the directory that contains the installation program:

```
$ ./openshift-install create ignition-configs --dir <installation_directory> 1
```

1 For **<installation_directory>**, specify the same installation directory.

Ignition config files are created for the bootstrap, control plane, and compute nodes in the installation directory. The **kubeadmin-password** and **kubeconfig** files are created in the **./<installation_directory>/auth** directory:

```
.
├── auth
│   ├── kubeadmin-password
│   └── kubeconfig
├── bootstrap.ign
├── master.ign
├── metadata.json
└── worker.ign
```

18.3.11. Installing RHCOS and starting the OpenShift Container Platform bootstrap process

To install OpenShift Container Platform on IBM Power infrastructure that you provision, you must install Red Hat Enterprise Linux CoreOS (RHCOS) on the machines. When you install RHCOS, you must provide the Ignition config file that was generated by the OpenShift Container Platform installation program for the type of machine you are installing. If you have configured suitable networking, DNS, and load balancing infrastructure, the OpenShift Container Platform bootstrap process begins automatically after the RHCOS machines have rebooted.

Follow either the steps to use an ISO image or network PXE booting to install RHCOS on the machines.

18.3.11.1. Installing RHCOS by using an ISO image

You can use an ISO image to install RHCOS on the machines.

Prerequisites

- You have created the Ignition config files for your cluster.
- You have configured suitable network, DNS and load balancing infrastructure.
- You have an HTTP server that can be accessed from your computer, and from the machines that you create.
- You have reviewed the *Advanced RHCOS installation configuration* section for different ways to configure features, such as networking and disk partitioning.

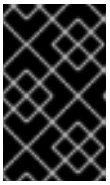
Procedure

1. Obtain the SHA512 digest for each of your Ignition config files. For example, you can use the following on a system running Linux to get the SHA512 digest for your **bootstrap.ign** Ignition config file:

```
$ sha512sum <installation_directory>/bootstrap.ign
```

The digests are provided to the **coreos-installer** in a later step to validate the authenticity of the Ignition config files on the cluster nodes.

2. Upload the bootstrap, control plane, and compute node Ignition config files that the installation program created to your HTTP server. Note the URLs of these files.



IMPORTANT

You can add or change configuration settings in your Ignition configs before saving them to your HTTP server. If you plan to add more compute machines to your cluster after you finish installation, do not delete these files.

3. From the installation host, validate that the Ignition config files are available on the URLs. The following example gets the Ignition config file for the bootstrap node:

```
$ curl -k http://<HTTP_server>/bootstrap.ign 1
```

Example output

```
  % Total    % Received % Xferd  Average Speed   Time    Time     Time  Current
                                 Dload  Upload   Total   Spent    Left  Speed
  0     0    0     0    0     0      0      0 --:--:-- --:--:-- --:--:--     0{"ignition":
{"version":"3.2.0"},"passwd":{"users":[{"name":"core","sshAuthorizedKeys":["ssh-rsa...
```

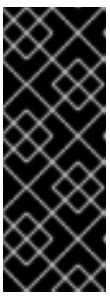
Replace **bootstrap.ign** with **master.ign** or **worker.ign** in the command to validate that the Ignition config files for the control plane and compute nodes are also available.

4. Although it is possible to obtain the RHCOS images that are required for your preferred method of installing operating system instances from the RHCOS image mirror page, the recommended way to obtain the correct version of your RHCOS images are from the output of **openshift-install** command:

```
$ openshift-install coreos print-stream-json | grep '\.iso[^.]'
```

Example output

```
"location": "<url>/art/storage/releases/rhcos-4.11-aarch64/<release>/aarch64/rhcos-
<release>-live.aarch64.iso",
"location": "<url>/art/storage/releases/rhcos-4.11-ppc64le/<release>/ppc64le/rhcos-
<release>-live.ppc64le.iso",
"location": "<url>/art/storage/releases/rhcos-4.11-s390x/<release>/s390x/rhcos-<release>-
live.s390x.iso",
"location": "<url>/art/storage/releases/rhcos-4.11/<release>/x86_64/rhcos-<release>-
live.x86_64.iso",
```



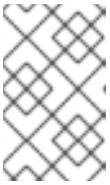
IMPORTANT

The RHCOS images might not change with every release of OpenShift Container Platform. You must download images with the highest version that is less than or equal to the OpenShift Container Platform version that you install. Use the image versions that match your OpenShift Container Platform version if they are available. Use only ISO images for this procedure. RHCOS qcow2 images are not supported for this installation type.

ISO file names resemble the following example:

rhcos-<version>-live.<architecture>.iso

5. Use the ISO to start the RHCOS installation. Use one of the following installation options:
   - Burn the ISO image to a disk and boot it directly.
   - Use ISO redirection by using a lights-out management (LOM) interface.
6. Boot the RHCOS ISO image without specifying any options or interrupting the live boot sequence. Wait for the installer to boot into a shell prompt in the RHCOS live environment.



NOTE

It is possible to interrupt the RHCOS installation boot process to add kernel arguments. However, for this ISO procedure you should use the **coreos-installer** command as outlined in the following steps, instead of adding kernel arguments.

7. Run the **coreos-installer** command and specify the options that meet your installation requirements. At a minimum, you must specify the URL that points to the Ignition config file for the node type, and the device that you are installing to:

```
$ sudo coreos-installer install --ignition-url=http://<HTTP_server>/<node_type>.ign <device>
--ignition-hash=sha512-<digest> 1 2
```

1 1 You must run the **coreos-installer** command by using **sudo**, because the **core** user does not have the required root privileges to perform the installation.

2 The **--ignition-hash** option is required when the Ignition config file is obtained through an HTTP URL to validate the authenticity of the Ignition config file on the cluster node. **<digest>** is the Ignition config file SHA512 digest obtained in a preceding step.

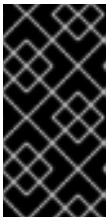
NOTE

If you want to provide your Ignition config files through an HTTPS server that uses TLS, you can add the internal certificate authority (CA) to the system trust store before running **coreos-installer**.

The following example initializes a bootstrap node installation to the **/dev/sda** device. The Ignition config file for the bootstrap node is obtained from an HTTP web server with the IP address 192.168.1.2:

```
$ sudo coreos-installer install --ignition-
url=http://192.168.1.2:80/installation_directory/bootstrap.ign /dev/sda --ignition-hash=sha512-
a5a2d43879223273c9b60af66b44202a1d1248fc01cf156c46d4a79f552b6bad47bc8cc78ddf011
6e80c59d2ea9e32ba53bc807afbca581aa059311def2c3e3b
```

8. Monitor the progress of the RHCOS installation on the console of the machine.



IMPORTANT

Be sure that the installation is successful on each node before commencing with the OpenShift Container Platform installation. Observing the installation process can also help to determine the cause of RHCOS installation issues that might arise.

9. After RHCOS installs, you must reboot the system. During the system reboot, it applies the Ignition config file that you specified.

10. Check the console output to verify that Ignition ran.

Example command

```
Ignition: ran on 2022/03/14 14:48:33 UTC (this boot)
Ignition: user-provided config was applied
```

11. Continue to create the other machines for your cluster.

IMPORTANT

You must create the bootstrap and control plane machines at this time. If the control plane machines are not made schedulable, also create at least two compute machines before you install OpenShift Container Platform.

If the required network, DNS, and load balancer infrastructure are in place, the OpenShift Container Platform bootstrap process begins automatically after the RHCOS nodes have rebooted.

NOTE

RHCOS nodes do not include a default password for the **core** user. You can access the nodes by running **ssh core@<node>.<cluster_name>.<base_domain>** as a user with access to the SSH private key that is paired to the public key that you specified in your **install_config.yaml** file. OpenShift Container Platform 4 cluster nodes running RHCOS are immutable and rely on Operators to apply cluster changes. Accessing cluster nodes by using SSH is not recommended. However, when investigating installation issues, if the OpenShift Container Platform API is not available, or the kubelet is not properly functioning on a target node, SSH access might be required for debugging or disaster recovery.

18.3.11.1.1. Advanced RHCOS installation reference

This section illustrates the networking configuration and other advanced options that allow you to modify the Red Hat Enterprise Linux CoreOS (RHCOS) manual installation process. The following tables describe the kernel arguments and command-line options you can use with the RHCOS live installer and the **coreos-installer** command.

18.3.11.1.1.1. Networking and bonding options for ISO installations

If you install RHCOS from an ISO image, you can add kernel arguments manually when you boot the image to configure networking for a node. If no networking arguments are specified, DHCP is activated in the initramfs when RHCOS detects that networking is required to fetch the Ignition config file.

IMPORTANT

When adding networking arguments manually, you must also add the **rd.neednet=1** kernel argument to bring the network up in the initramfs.

The following information provides examples for configuring networking and bonding on your RHCOS nodes for ISO installations. The examples describe how to use the **ip=**, **nameserver=**, and **bond=** kernel arguments.

NOTE

Ordering is important when adding the kernel arguments: **ip=**, **nameserver=**, and then **bond=**.

The networking options are passed to the **dracut** tool during system boot. For more information about the networking options supported by **dracut**, see the **dracut.cmdline** manual page.

The following examples are the networking options for ISO installation.

Configuring DHCP or static IP addresses
To configure an IP address, either use DHCP (**ip=dhcp**) or set an individual static IP address (**ip=<host_ip>**). If setting a static IP, you must then identify the DNS server IP address (**nameserver=<dns_ip>**) on each node. The following example sets:

- The node's IP address to **10.10.10.2**
- The gateway address to **10.10.10.254**
- The netmask to **255.255.255.0**
- The hostname to **core0.example.com**
- The DNS server address to **4.4.4.41**
- The auto-configuration value to **none**. No auto-configuration is required when IP networking is configured statically.

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp1s0:none
nameserver=4.4.4.41
```

NOTE

When you use DHCP to configure IP addressing for the RHCOS machines, the machines also obtain the DNS server information through DHCP. For DHCP-based deployments, you can define the DNS server address that is used by the RHCOS nodes through your DHCP server configuration.

Configuring an IP address without a static hostname
You can configure an IP address without assigning a static hostname. If a static hostname is not set by the user, it will be picked up and automatically set by a reverse DNS lookup. To configure an IP address without a static hostname refer to the following example:

- The node's IP address to **10.10.10.2**

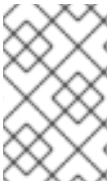
- The gateway address to **10.10.10.254**
- The netmask to **255.255.255.0**
- The DNS server address to **4.4.4.41**
- The auto-configuration value to **none**. No auto-configuration is required when IP networking is configured statically.

```
ip=10.10.10.2::10.10.10.254:255.255.255.0::enp1s0:none
nameserver=4.4.4.41
```

Specifying multiple network interfaces
You can specify multiple network interfaces by setting multiple **ip=** entries.

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp1s0:none
ip=10.10.10.3::10.10.10.254:255.255.255.0:core0.example.com:enp2s0:none
```

Configuring default gateway and route
Optional: You can configure routes to additional networks by setting an **rd.route=** value.



NOTE

When you configure one or multiple networks, one default gateway is required. If the additional network gateway is different from the primary network gateway, the default gateway must be the primary network gateway.

- Run the following command to configure the default gateway:

```
ip=::10.10.10.254::::
```

- Enter the following command to configure the route for the additional network:

```
rd.route=20.20.20.0/24:20.20.20.254:enp2s0
```

Disabling DHCP on a single interface
You can disable DHCP on a single interface, such as when there are two or more network interfaces and only one interface is being used. In the example, the **enp1s0** interface has a static networking configuration and DHCP is disabled for **enp2s0**, which is not used:

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp1s0:none
ip=::::core0.example.com:enp2s0:none
```

Combining DHCP and static IP configurations
You can combine DHCP and static IP configurations on systems with multiple network interfaces, for example:

```
ip=enp1s0:dhcp
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp2s0:none
```

Configuring VLANs on individual interfaces
Optional: You can configure VLANs on individual interfaces by using the **vlan=** parameter.

- To configure a VLAN on a network interface and use a static IP address, run the following command:

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp2s0.100:none
vlan=enp2s0.100:enp2s0
```

- To configure a VLAN on a network interface and to use DHCP, run the following command:

```
ip=enp2s0.100:dhcp
vlan=enp2s0.100:enp2s0
```

Providing multiple DNS servers
You can provide multiple DNS servers by adding a **nameserver=** entry for each server, for example:

```
nameserver=1.1.1.1
nameserver=8.8.8.8
```

Bonding multiple network interfaces to a single interface
Optional: You can bond multiple network interfaces to a single interface by using the **bond=** option. Refer to the following examples:

- The syntax for configuring a bonded interface is: **bond=name[:network_interfaces][:options]** *name* is the bonding device name (**bond0**), *network_interfaces* represents a comma-separated list of physical (ethernet) interfaces (**em1,em2**), and *options* is a comma-separated list of bonding options. Enter **modinfo bonding** to see available options.

- When you create a bonded interface using **bond=**, you must specify how the IP address is assigned and other information for the bonded interface.

- To configure the bonded interface to use DHCP, set the bond's IP address to **dhcp**. For example:

```
bond=bond0:em1,em2:mode=active-backup
ip=bond0:dhcp
```

- To configure the bonded interface to use a static IP address, enter the specific IP address you want and related information. For example:

```
bond=bond0:em1,em2:mode=active-backup
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:bond0:none
```

Bonding multiple network interfaces to a single interface
Optional: You can configure VLANs on bonded interfaces by using the **vlan=** parameter and to use DHCP, for example:

```
ip=bond0.100:dhcp
bond=bond0:em1,em2:mode=active-backup
vlan=bond0.100:bond0
```

Use the following example to configure the bonded interface with a VLAN and to use a static IP address:

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:bond0.100:none
bond=bond0:em1,em2:mode=active-backup
vlan=bond0.100:bond0
```

Using network teaming
Optional: You can use a network teaming as an alternative to bonding by using the **team=** parameter:

- The syntax for configuring a team interface is: **team=name[:network_interfaces]**
  name is the team device name (**team0**) and *network_interfaces* represents a comma-separated list of physical (ethernet) interfaces (**em1, em2**).

NOTE

Teaming is planned to be deprecated when RHCOS switches to an upcoming version of RHEL. For more information, see this Red Hat Knowledgebase Article .

Use the following example to configure a network team:

```
team=team0:em1,em2
ip=team0:dhcp
```

18.3.11.2. Installing RHCOS by using PXE booting

You can use PXE booting to install RHCOS on the machines.

Prerequisites

- You have created the Ignition config files for your cluster.
- You have configured suitable network, DNS and load balancing infrastructure.
- You have configured suitable PXE infrastructure.
- You have an HTTP server that can be accessed from your computer, and from the machines that you create.
- You have reviewed the *Advanced RHCOS installation configuration* section for different ways to configure features, such as networking and disk partitioning.

Procedure

1. Upload the bootstrap, control plane, and compute node Ignition config files that the installation program created to your HTTP server. Note the URLs of these files.

IMPORTANT

You can add or change configuration settings in your Ignition configs before saving them to your HTTP server. If you plan to add more compute machines to your cluster after you finish installation, do not delete these files.

2. From the installation host, validate that the Ignition config files are available on the URLs. The following example gets the Ignition config file for the bootstrap node:

```
$ curl -k http://<HTTP_server>/bootstrap.ign 1
```

Example output

```
  % Total    % Received % Xferd  Average Speed   Time    Time     Time  Current
                                 Dload  Upload   Total   Spent    Left  Speed
  0     0    0     0    0     0      0      0 --:--:-- --:--:-- --:--:--     0{"ignition":
{"version":"3.2.0"},"passwd":{"users":[{"name":"core","sshAuthorizedKeys":["ssh-rsa...
```

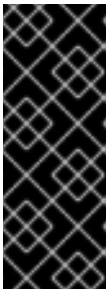
Replace **bootstrap.ign** with **master.ign** or **worker.ign** in the command to validate that the Ignition config files for the control plane and compute nodes are also available.

3. Although it is possible to obtain the RHCOS **kernel**, **initramfs** and **rootfs** files that are required for your preferred method of installing operating system instances from the RHCOS image mirror page, the recommended way to obtain the correct version of your RHCOS files are from the output of **openshift-install** command:

```
$ openshift-install coreos print-stream-json | grep -Eo '"https.*(kernel-|initramfs.|rootfs.)\w+
(\.img)?"'
```

Example output

```
"<url>/art/storage/releases/rhcos-4.11-aarch64/<release>/aarch64/rhcos-<release>-live-
kernel-aarch64"
"<url>/art/storage/releases/rhcos-4.11-aarch64/<release>/aarch64/rhcos-<release>-live-
initramfs.aarch64.img"
"<url>/art/storage/releases/rhcos-4.11-aarch64/<release>/aarch64/rhcos-<release>-live-
rootfs.aarch64.img"
"<url>/art/storage/releases/rhcos-4.11-ppc64le/49.84.202110081256-0/ppc64le/rhcos-
<release>-live-kernel-ppc64le"
"<url>/art/storage/releases/rhcos-4.11-ppc64le/<release>/ppc64le/rhcos-<release>-live-
initramfs.ppc64le.img"
"<url>/art/storage/releases/rhcos-4.11-ppc64le/<release>/ppc64le/rhcos-<release>-live-
rootfs.ppc64le.img"
"<url>/art/storage/releases/rhcos-4.11-s390x/<release>/s390x/rhcos-<release>-live-kernel-
s390x"
"<url>/art/storage/releases/rhcos-4.11-s390x/<release>/s390x/rhcos-<release>-live-
initramfs.s390x.img"
"<url>/art/storage/releases/rhcos-4.11-s390x/<release>/s390x/rhcos-<release>-live-
rootfs.s390x.img"
"<url>/art/storage/releases/rhcos-4.11/<release>/x86_64/rhcos-<release>-live-kernel-
x86_64"
"<url>/art/storage/releases/rhcos-4.11/<release>/x86_64/rhcos-<release>-live-
initramfs.x86_64.img"
"<url>/art/storage/releases/rhcos-4.11/<release>/x86_64/rhcos-<release>-live-
rootfs.x86_64.img"
```



IMPORTANT

The RHCOS artifacts might not change with every release of OpenShift Container Platform. You must download images with the highest version that is less than or equal to the OpenShift Container Platform version that you install. Only use the appropriate **kernel**, **initramfs**, and **rootfs** artifacts described below for this procedure. RHCOS QCOW2 images are not supported for this installation type.

The file names contain the OpenShift Container Platform version number. They resemble the following examples:

- **kernel**: **rhcos-<version>-live-kernel-<architecture>**
- **initramfs**: **rhcos-<version>-live-initramfs.<architecture>.img**
- **rootfs**: **rhcos-<version>-live-rootfs.<architecture>.img**

4. Upload the **rootfs**, **kernel**, and **initramfs** files to your HTTP server.

IMPORTANT

If you plan to add more compute machines to your cluster after you finish installation, do not delete these files.

5. Configure the network boot infrastructure so that the machines boot from their local disks after RHCOS is installed on them.

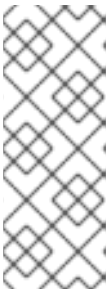
6. Configure PXE installation for the RHCOS images and begin the installation.
Modify the following example menu entry for your environment and verify that the image and Ignition files are properly accessible:

```
DEFAULT pxeboot
TIMEOUT 20
PROMPT 0
LABEL pxeboot
    KERNEL http://<HTTP_server>/rhcos-<version>-live-kernel-<architecture> (1)
    APPEND initrd=http://<HTTP_server>/rhcos-<version>-live-initramfs.<architecture>.img
coreos.live.rootfs_url=http://<HTTP_server>/rhcos-<version>-live-rootfs.<architecture>.img
coreos.inst.install_dev=/dev/sda coreos.inst.ignition_url=http://<HTTP_server>/bootstrap.ign
(2) (3)
```

(1) (1) Specify the location of the live **kernel** file that you uploaded to your HTTP server. The URL must be HTTP, TFTP, or FTP; HTTPS and NFS are not supported.

(2) If you use multiple NICs, specify a single interface in the **ip** option. For example, to use DHCP on a NIC that is named **eno1**, set **ip=eno1:dhcp**.

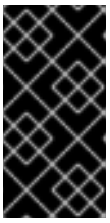
(3) Specify the locations of the RHCOS files that you uploaded to your HTTP server. The **initrd** parameter value is the location of the **initramfs** file, the **coreos.live.rootfs_url** parameter value is the location of the **rootfs** file, and the **coreos.inst.ignition_url** parameter value is the location of the bootstrap Ignition config file. You can also add more kernel arguments to the **APPEND** line to configure networking or other boot options.



NOTE

This configuration does not enable serial console access on machines with a graphical console. To configure a different console, add one or more **console=** arguments to the **APPEND** line. For example, add **console=tty0 console=ttyS0** to set the first PC serial port as the primary console and the graphical console as a secondary console. For more information, see How does one set up a serial terminal and/or console in Red Hat Enterprise Linux?.

7. Monitor the progress of the RHCOS installation on the console of the machine.



IMPORTANT

Be sure that the installation is successful on each node before commencing with the OpenShift Container Platform installation. Observing the installation process can also help to determine the cause of RHCOS installation issues that might arise.

8. After RHCOS installs, the system reboots. During reboot, the system applies the Ignition config file that you specified.

9. Check the console output to verify that Ignition ran.

Example command

```
Ignition: ran on 2022/03/14 14:48:33 UTC (this boot)
Ignition: user-provided config was applied
```

10. Continue to create the machines for your cluster.

IMPORTANT

You must create the bootstrap and control plane machines at this time. If the control plane machines are not made schedulable, also create at least two compute machines before you install the cluster.

If the required network, DNS, and load balancer infrastructure are in place, the OpenShift Container Platform bootstrap process begins automatically after the RHCOS nodes have rebooted.

NOTE

RHCOS nodes do not include a default password for the **core** user. You can access the nodes by running **ssh core@<node>.<cluster_name>.<base_domain>** as a user with access to the SSH private key that is paired to the public key that you specified in your **install_config.yaml** file. OpenShift Container Platform 4 cluster nodes running RHCOS are immutable and rely on Operators to apply cluster changes. Accessing cluster nodes by using SSH is not recommended. However, when investigating installation issues, if the OpenShift Container Platform API is not available, or the kubelet is not properly functioning on a target node, SSH access might be required for debugging or disaster recovery.

18.3.11.3. Enabling multipathing with kernel arguments on RHCOS

In OpenShift Container Platform 4.9 or later, during installation, you can enable multipathing for provisioned nodes. RHCOS supports multipathing on the primary disk. Multipathing provides added benefits of stronger resilience to hardware failure to achieve higher host availability.

During the initial cluster creation, you might want to add kernel arguments to all master or worker nodes. To add kernel arguments to master or worker nodes, you can create a **MachineConfig** object and inject that object into the set of manifest files used by Ignition during cluster setup.

Procedure

1. Change to the directory that contains the installation program and generate the Kubernetes manifests for the cluster:

```
$ ./openshift-install create manifests --dir <installation_directory>
```

2. Decide if you want to add kernel arguments to worker or control plane nodes.

   - Create a machine config file. For example, create a **99-master-kargs-mpath.yaml** that instructs the cluster to add the **master** label and identify the multipath kernel argument:

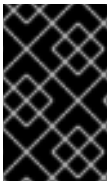
```
apiVersion: machineconfiguration.openshift.io/v1
kind: MachineConfig
metadata:
  labels:
    machineconfiguration.openshift.io/role: "master"
  name: 99-master-kargs-mpath
spec:
  kernelArguments:
    - 'rd.multipath=default'
    - 'root=/dev/disk/by-label/dm-mpath-root'
```

3. To enable multipathing on worker nodes:

   - Create a machine config file. For example, create a **99-worker-kargs-mpath.yaml** that instructs the cluster to add the **worker** label and identify the multipath kernel argument:

```
apiVersion: machineconfiguration.openshift.io/v1
kind: MachineConfig
metadata:
  labels:
    machineconfiguration.openshift.io/role: "worker"
  name: 99-worker-kargs-mpath
spec:
  kernelArguments:
    - 'rd.multipath=default'
    - 'root=/dev/disk/by-label/dm-mpath-root'
```

   You can now continue on to create the cluster.



IMPORTANT

Additional postinstallation steps are required to fully enable multipathing. For more information, see “Enabling multipathing with kernel arguments on RHCOS" in *Postinstallation machine configuration tasks*.

In case of MPIO failure, use the bootlist command to update the boot device list with alternate logical device names. The command displays a boot list and it designates the possible boot devices for when the system is booted in normal mode.

a. To display a boot list and specify the possible boot devices if the system is booted in normal mode, enter the following command:

```
$ bootlist -m normal -o
sda
```

b. To update the boot list for normal mode and add alternate device names, enter the following command:

```
$ bootlist -m normal -o /dev/sdc /dev/sdd /dev/sde
sdc
sdd
sde
```

If the original boot disk path is down, the node reboots from the alternate device registered in the normal boot device list.

18.3.12. Waiting for the bootstrap process to complete

The OpenShift Container Platform bootstrap process begins after the cluster nodes first boot into the persistent RHCOS environment that has been installed to disk. The configuration information provided through the Ignition config files is used to initialize the bootstrap process and install OpenShift Container Platform on the machines. You must wait for the bootstrap process to complete.

Prerequisites

- You have created the Ignition config files for your cluster.
- You have configured suitable network, DNS and load balancing infrastructure.
- You have obtained the installation program and generated the Ignition config files for your cluster.
- You installed RHCOS on your cluster machines and provided the Ignition config files that the OpenShift Container Platform installation program generated.

Procedure

1. Monitor the bootstrap process:

```
$ ./openshift-install --dir <installation_directory> wait-for bootstrap-complete \ 1
    --log-level=info 2
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

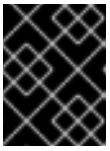
2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

Example output

```
INFO Waiting up to 30m0s for the Kubernetes API at https://api.test.example.com:6443...
INFO API v1.24.0 up
INFO Waiting up to 30m0s for bootstrapping to complete...
INFO It is now safe to remove the bootstrap resources
```

The command succeeds when the Kubernetes API server signals that it has been bootstrapped on the control plane machines.

2. After the bootstrap process is complete, remove the bootstrap machine from the load balancer.



IMPORTANT

You must remove the bootstrap machine from the load balancer at this point. You can also remove or reformat the bootstrap machine itself.

18.3.13. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

Example output

```
system:admin
```

18.3.14. Approving the certificate signing requests for your machines

When you add machines to a cluster, two pending certificate signing requests (CSRs) are generated for each machine that you added. You must confirm that these CSRs are approved or, if necessary, approve them yourself. The client requests must be approved first, followed by the server requests.

Prerequisites

- You added machines to your cluster.

Procedure

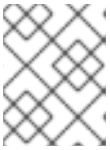
1. Confirm that the cluster recognizes the machines:

```
$ oc get nodes
```

Example output

```
NAME      STATUS    ROLES   AGE  VERSION
master-0  Ready     master  63m  v1.24.0
master-1  Ready     master  63m  v1.24.0
master-2  Ready     master  64m  v1.24.0
```

The output lists all of the machines that you created.



NOTE

The preceding output might not include the compute nodes, also known as worker nodes, until some CSRs are approved.

2. Review the pending CSRs and ensure that you see the client requests with the **Pending** or **Approved** status for each machine that you added to the cluster:

```
$ oc get csr
```

Example output

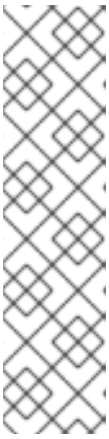
```
NAME        AGE     REQUESTOR                                                   CONDITION
csr-8b2br   15m     system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper   Pending
csr-8vnps   15m     system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper   Pending
...
```

In this example, two machines are joining the cluster. You might see more approved CSRs in the list.

3. If the CSRs were not approved, after all of the pending CSRs for the machines you added are in **Pending** status, approve the CSRs for your cluster machines:

NOTE

Because the CSRs rotate automatically, approve your CSRs within an hour of adding the machines to the cluster. If you do not approve them within an hour, the certificates will rotate, and more than two certificates will be present for each node. You must approve all of these certificates. After the client CSR is approved, the Kubelet creates a secondary CSR for the serving certificate, which requires manual approval. Then, subsequent serving certificate renewal requests are automatically approved by the **machine-approver** if the Kubelet requests a new certificate with identical parameters.



NOTE

For clusters running on platforms that are not machine API enabled, such as bare metal and other user-provisioned infrastructure, you must implement a method of automatically approving the kubelet serving certificate requests (CSRs). If a request is not approved, then the **oc exec**, **oc rsh**, and **oc logs** commands cannot succeed, because a serving certificate is required when the API server connects to the kubelet. Any operation that contacts the Kubelet endpoint requires this certificate approval to be in place. The method must watch for new CSRs, confirm that the CSR was submitted by the **node-bootstrapper** service account in the **system:node** or **system:admin** groups, and confirm the identity of the node.

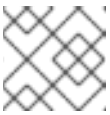
- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

1 **<csr_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{{"\n"}}
{{end}}{{end}}' | xargs --no-run-if-empty oc adm certificate approve
```



NOTE

Some Operators might not become available until some CSRs are approved.

4. Now that your client requests are approved, you must review the server requests for each machine that you added to the cluster:

```
$ oc get csr
```

Example output

```
NAME        AGE     REQUESTOR                                                   CONDITION
csr-bfd72   5m26s   system:node:ip-10-0-50-126.us-east-2.compute.internal
Pending
csr-c57lv   5m26s   system:node:ip-10-0-95-157.us-east-2.compute.internal
Pending
...
```

5. If the remaining CSRs are not approved, and are in the **Pending** status, approve the CSRs for your cluster machines:

   - To approve them individually, run the following command for each valid CSR:

     ```
     $ oc adm certificate approve <csr_name> 1
     ```

     1 **<csr_name>** is the name of a CSR from the list of current CSRs.

   - To approve all pending CSRs, run the following command:

     ```
     $ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{{"\n"}}
     {{end}}{{end}}' | xargs oc adm certificate approve
     ```

6. After all client and server CSRs have been approved, the machines have the **Ready** status. Verify this by running the following command:

   ```
   $ oc get nodes
   ```

   Example output

   ```
   NAME      STATUS    ROLES   AGE  VERSION
   master-0  Ready     master  73m  v1.24.0
   master-1  Ready     master  73m  v1.24.0
   master-2  Ready     master  74m  v1.24.0
   worker-0  Ready     worker  11m  v1.24.0
   worker-1  Ready     worker  11m  v1.24.0
   ```

   NOTE

   It can take a few minutes after approval of the server CSRs for the machines to transition to the **Ready** status.

Additional information

- For more information on CSRs, see Certificate Signing Requests.

18.3.15. Initial Operator configuration

After the control plane initializes, you must immediately configure some Operators so that they all become available.

Prerequisites

- Your control plane has initialized.

Procedure

1. Watch the cluster components come online:

   ```
   $ watch -n5 oc get clusteroperators
   ```

Example output

```
NAME                                       VERSION   AVAILABLE   PROGRESSING   DEGRADED
SINCE
authentication                             4.11.0    True        False         False      19m
baremetal                                  4.11.0    True        False         False      37m
cloud-credential                           4.11.0    True        False         False      40m
cluster-autoscaler                         4.11.0    True        False         False      37m
config-operator                            4.11.0    True        False         False      38m
console                                    4.11.0    True        False         False      26m
csi-snapshot-controller                    4.11.0    True        False         False      37m
dns                                        4.11.0    True        False         False      37m
etcd                                       4.11.0    True        False         False      36m
image-registry                             4.11.0    True        False         False      31m
ingress                                    4.11.0    True        False         False      30m
insights                                   4.11.0    True        False         False      31m
kube-apiserver                             4.11.0    True        False         False      26m
kube-controller-manager                    4.11.0    True        False         False      36m
kube-scheduler                             4.11.0    True        False         False      36m
kube-storage-version-migrator              4.11.0    True        False         False      37m
machine-api                                4.11.0    True        False         False      29m
machine-approver                           4.11.0    True        False         False      37m
machine-config                             4.11.0    True        False         False      36m
marketplace                                4.11.0    True        False         False      37m
monitoring                                 4.11.0    True        False         False      29m
network                                    4.11.0    True        False         False      38m
node-tuning                                4.11.0    True        False         False      37m
openshift-apiserver                        4.11.0    True        False         False      32m
openshift-controller-manager               4.11.0    True        False         False      30m
openshift-samples                          4.11.0    True        False         False      32m
operator-lifecycle-manager                 4.11.0    True        False         False      37m
operator-lifecycle-manager-catalog         4.11.0    True        False         False      37m
operator-lifecycle-manager-packageserver   4.11.0    True        False         False      32m
service-ca                                 4.11.0    True        False         False      38m
storage                                    4.11.0    True        False         False      37m
```

2. Configure the Operators that are not available.

18.3.15.1. Disabling the default OperatorHub sources

Operator catalogs that source content provided by Red Hat and community projects are configured for OperatorHub by default during an OpenShift Container Platform installation. In a restricted network environment, you must disable the default catalogs as a cluster administrator.

Procedure

- Disable the sources for the default catalogs by adding **disableAllDefaultSources: true** to the **OperatorHub** object:

```
$ oc patch OperatorHub cluster --type json \
    -p '[{"op": "add", "path": "/spec/disableAllDefaultSources", "value": true}]'
```

TIP

Alternatively, you can use the web console to manage catalog sources. From the **Administration → Cluster Settings → Configuration → OperatorHub** page, click the **Sources** tab, where you can create, update, delete, disable, and enable individual sources.

18.3.15.2. Image registry storage configuration

The Image Registry Operator is not initially available for platforms that do not provide default storage. After installation, you must configure your registry to use storage so that the Registry Operator is made available.

Instructions are shown for configuring a persistent volume, which is required for production clusters. Where applicable, instructions are shown for configuring an empty directory as the storage location, which is available for only non-production clusters.

Additional instructions are provided for allowing the image registry to use block storage types by using the **Recreate** rollout strategy during upgrades.

18.3.15.2.1. Changing the image registry's management state

To start the image registry, you must change the Image Registry Operator configuration's **managementState** from **Removed** to **Managed**.

Procedure

- Change **managementState** Image Registry Operator configuration from **Removed** to **Managed**. For example:

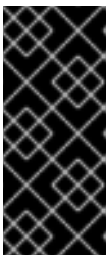
```
$ oc patch configs.imageregistry.operator.openshift.io cluster --type merge --patch '{"spec":
{"managementState":"Managed"}}'
```

18.3.15.2.2. Configuring registry storage for IBM Power

As a cluster administrator, following installation you must configure your registry to use storage.

Prerequisites

- You have access to the cluster as a user with the **cluster-admin** role.
- You have a cluster on IBM Power.
- You have provisioned persistent storage for your cluster, such as Red Hat OpenShift Data Foundation.



IMPORTANT

OpenShift Container Platform supports **ReadWriteOnce** access for image registry storage when you have only one replica. **ReadWriteOnce** access also requires that the registry uses the **Recreate** rollout strategy. To deploy an image registry that supports high availability with two or more replicas, **ReadWriteMany** access is required.

- Must have 100Gi capacity.

Procedure

1. To configure your registry to use storage, change the **spec.storage.pvc** in the **configs.imageregistry/cluster** resource.

NOTE

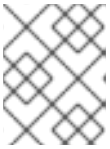
When you use shared storage, review your security settings to prevent outside access.

2. Verify that you do not have a registry pod:

```
$ oc get pod -n openshift-image-registry -l docker-registry=default
```

Example output

```
No resourses found in openshift-image-registry namespace
```



NOTE

If you do have a registry pod in your output, you do not need to continue with this procedure.

3. Check the registry configuration:

```
$ oc edit configs.imageregistry.operator.openshift.io
```

Example output

```
storage:
  pvc:
    claim:
```

Leave the **claim** field blank to allow the automatic creation of an **image-registry-storage** PVC.

4. Check the **clusteroperator** status:

```
$ oc get clusteroperator image-registry
```

Example output

```
NAME             VERSION       AVAILABLE   PROGRESSING   DEGRADED   SINCE
MESSAGE
image-registry   4.11          True        False         False      6h50m
```

5. Ensure that your registry is set to managed to enable building and pushing of images.

- Run:

```
$ oc edit configs.imageregistry/cluster
```

Then, change the line

```
managementState: Removed
```

to

```
managementState: Managed
```

18.3.15.2.3. Configuring storage for the image registry in non-production clusters

You must configure storage for the Image Registry Operator. For non-production clusters, you can set the image registry to an empty directory. If you do so, all images are lost if you restart the registry.

Procedure

- To set the image registry storage to an empty directory:

```
$ oc patch configs.imageregistry.operator.openshift.io cluster --type merge --patch '{"spec":{"storage":{"emptyDir":{}}}}'
```

> **WARNING**
>
> Configure this option for only non-production clusters.

If you run this command before the Image Registry Operator initializes its components, the **oc patch** command fails with the following error:

```
Error from server (NotFound): configs.imageregistry.operator.openshift.io "cluster" not found
```

Wait a few minutes and run the command again.

18.3.16. Completing installation on user-provisioned infrastructure

After you complete the Operator configuration, you can finish installing the cluster on infrastructure that you provide.

Prerequisites

- Your control plane has initialized.
- You have completed the initial Operator configuration.

Procedure

1. Confirm that all the cluster components are online with the following command:

```
$ watch -n5 oc get clusteroperators
```

Example output

```
NAME                                       VERSION   AVAILABLE   PROGRESSING   DEGRADED
SINCE
authentication                             4.11.0    True        False         False      19m
baremetal                                  4.11.0    True        False         False      37m
cloud-credential                           4.11.0    True        False         False      40m
cluster-autoscaler                         4.11.0    True        False         False      37m
config-operator                            4.11.0    True        False         False      38m
console                                    4.11.0    True        False         False      26m
csi-snapshot-controller                    4.11.0    True        False         False      37m
dns                                        4.11.0    True        False         False      37m
etcd                                       4.11.0    True        False         False      36m
image-registry                             4.11.0    True        False         False      31m
ingress                                    4.11.0    True        False         False      30m
insights                                   4.11.0    True        False         False      31m
kube-apiserver                             4.11.0    True        False         False      26m
kube-controller-manager                    4.11.0    True        False         False      36m
kube-scheduler                             4.11.0    True        False         False      36m
kube-storage-version-migrator              4.11.0    True        False         False      37m
machine-api                                4.11.0    True        False         False      29m
machine-approver                           4.11.0    True        False         False      37m
machine-config                             4.11.0    True        False         False      36m
marketplace                                4.11.0    True        False         False      37m
monitoring                                 4.11.0    True        False         False      29m
network                                    4.11.0    True        False         False      38m
node-tuning                                4.11.0    True        False         False      37m
openshift-apiserver                        4.11.0    True        False         False      32m
openshift-controller-manager               4.11.0    True        False         False      30m
openshift-samples                          4.11.0    True        False         False      32m
operator-lifecycle-manager                 4.11.0    True        False         False      37m
operator-lifecycle-manager-catalog         4.11.0    True        False         False      37m
operator-lifecycle-manager-packageserver   4.11.0    True        False         False      32m
service-ca                                 4.11.0    True        False         False      38m
storage                                    4.11.0    True        False         False      37m
```

Alternatively, the following command notifies you when all of the clusters are available. It also retrieves and displays credentials:

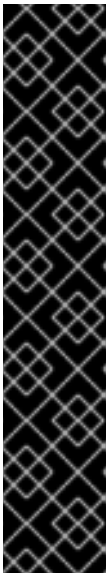
```
$ ./openshift-install --dir <installation_directory> wait-for install-complete 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

Example output

```
INFO Waiting up to 30m0s for the cluster to initialize...
```

The command succeeds when the Cluster Version Operator finishes deploying the OpenShift Container Platform cluster from Kubernetes API server.



IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

2. Confirm that the Kubernetes API server is communicating with the pods.

   a. To view a list of all pods, use the following command:

   ```
   $ oc get pods --all-namespaces
   ```

   Example output

   ```
   NAMESPACE                       NAME                                        READY   STATUS
   RESTARTS   AGE
   openshift-apiserver-operator    openshift-apiserver-operator-85cb746d55-zqhs8   1/1
   Running    1          9m
   openshift-apiserver             apiserver-67b9g                               1/1     Running     0
   3m
   openshift-apiserver             apiserver-ljcmx                               1/1     Running     0
   1m
   openshift-apiserver             apiserver-z25h4                               1/1     Running     0
   2m
   openshift-authentication-operator authentication-operator-69d5d8bf84-vh2n8        1/1
   Running    0          5m
   ...
   ```

   b. View the logs for a pod that is listed in the output of the previous command by using the following command:

   ```
   $ oc logs <pod_name> -n <namespace>
   ```
   (1)

   (1) Specify the pod name and namespace, as shown in the output of the previous command.

   If the pod logs display, the Kubernetes API server can communicate with the cluster machines.

3. Additional steps are required to enable multipathing. Do not enable multipathing during installation.
   See "Enabling multipathing with kernel arguments on RHCOS" in the *Post-installation machine configuration tasks* documentation for more information.

4. Register your cluster on the Cluster registration page.

18.3.17. Next steps

- Enabling multipathing with kernel arguments on RHCOS .
- Customize your cluster.
- If the mirror registry that you used to install your cluster has a trusted CA, add it to the cluster by configuring additional trust stores.
- If necessary, you can opt out of remote health reporting .
- If necessary, see Registering your disconnected cluster

CHAPTER 19. INSTALLING ON OPENSTACK

19.1. PREPARING TO INSTALL ON OPENSTACK

You can install OpenShift Container Platform on Red Hat OpenStack Platform (RHOSP).

19.1.1. Prerequisites

- You reviewed details about the OpenShift Container Platform installation and update processes.
- You read the documentation on selecting a cluster installation method and preparing it for users.

19.1.2. Choosing a method to install OpenShift Container Platform on OpenStack

You can install OpenShift Container Platform on installer-provisioned or user-provisioned infrastructure. The default installation type uses installer-provisioned infrastructure, where the installation program provisions the underlying infrastructure for the cluster. You can also install OpenShift Container Platform on infrastructure that you provision. If you do not use infrastructure that the installation program provisions, you must manage and maintain the cluster resources yourself.

See Installation process for more information about installer-provisioned and user-provisioned installation processes.

19.1.2.1. Installing a cluster on installer-provisioned infrastructure

You can install a cluster on Red Hat OpenStack Platform (RHOSP) infrastructure that is provisioned by the OpenShift Container Platform installation program, by using one of the following methods:

- **Installing a cluster on OpenStack with customizations**: You can install a customized cluster on RHOSP. The installation program allows for some customization to be applied at the installation stage. Many other customization options are available post-installation.
- **Installing a cluster on OpenStack with Kuryr**: You can install a customized OpenShift Container Platform cluster on RHOSP that uses Kuryr SDN. Kuryr and OpenShift Container Platform integration is primarily designed for OpenShift Container Platform clusters running on RHOSP VMs. Kuryr improves the network performance by plugging OpenShift Container Platform pods into RHOSP SDN. In addition, it provides interconnectivity between pods and RHOSP virtual instances.
- **Installing a cluster on OpenStack in a restricted network**: You can install OpenShift Container Platform on RHOSP in a restricted or disconnected network by creating an internal mirror of the installation release content. You can use this method to install a cluster that does not require an active internet connection to obtain the software components. You can also use this installation method to ensure that your clusters only use container images that satisfy your organizational controls on external content.

19.1.2.2. Installing a cluster on user-provisioned infrastructure

You can install a cluster on RHOSP infrastructure that you provision, by using one of the following methods:

- **Installing a cluster on OpenStack on your own infrastructure**: You can install OpenShift

Container Platform on user-provisioned RHOSP infrastructure. By using this installation method, you can integrate your cluster with existing infrastructure and modifications. For installations on user-provisioned infrastructure, you must create all RHOSP resources, like Nova servers, Neutron ports, and security groups. You can use the provided Ansible playbooks to assist with the deployment process.

- **Installing a cluster on OpenStack with Kuryr on your own infrastructure** You can install OpenShift Container Platform on user-provisioned RHOSP infrastructure that uses Kuryr SDN.

19.1.3. Scanning RHOSP endpoints for legacy HTTPS certificates

Beginning with OpenShift Container Platform 4.10, HTTPS certificates must contain subject alternative name (SAN) fields. Run the following script to scan each HTTPS endpoint in a Red Hat OpenStack Platform (RHOSP) catalog for legacy certificates that only contain the **CommonName** field.

IMPORTANT

OpenShift Container Platform does not check the underlying RHOSP infrastructure for legacy certificates prior to installation or updates. Use the provided script to check for these certificates yourself. Failing to update legacy certificates prior to installing or updating a cluster will result in cluster dysfunction.

Prerequisites

- On the machine where you run the script, have the following software:
  - Bash version 4.0 or greater
  - **grep**
  - OpenStack client
  - **jq**
  - OpenSSL version 1.1.1l or greater
- Populate the machine with RHOSP credentials for the target cloud.

Procedure

1. Save the following script to your machine:

```
#!/usr/bin/env bash

set -Eeuo pipefail

declare catalog san
catalog="$(mktemp)"
san="$(mktemp)"
readonly catalog san

declare invalid=0

openstack catalog list --format json --column Name --column Endpoints \
 | jq -r '.[] | .Name as $name | .Endpoints[] | select(.interface=="public") | [$name, .interface,
```

```
.url] | join(" ")' \
 | sort \
 > "$catalog"

while read -r name interface url; do
 # Ignore HTTP
 if [[ ${url#"http://"} != "$url" ]]; then
  continue
 fi

 # Remove the schema from the URL
 noschema=${url#"https://"}

 # If the schema was not HTTPS, error
 if [[ "$noschema" == "$url" ]]; then
  echo "ERROR (unknown schema): $name $interface $url"
  exit 2
 fi

 # Remove the path and only keep host and port
 noschema="${noschema%%/*}"
 host="${noschema%%:*}"
 port="${noschema##*:}"

 # Add the port if was implicit
 if [[ "$port" == "$host" ]]; then
  port='443'
 fi

 # Get the SAN fields
 openssl s_client -showcerts -servername "$host" -connect "$host:$port" </dev/null
2>/dev/null \
  | openssl x509 -noout -ext subjectAltName \
  > "$san"

 # openssl returns the empty string if no SAN is found.
 # If a SAN is found, openssl is expected to return something like:
 #
 #    X509v3 Subject Alternative Name:
 #        DNS:standalone, DNS:osp1, IP Address:192.168.2.1, IP Address:10.254.1.2
 if [[ "$(grep -c "Subject Alternative Name" "$san" || true)" -gt 0 ]]; then
  echo "PASS: $name $interface $url"
 else
  invalid=$((invalid+1))
  echo "INVALID: $name $interface $url"
 fi
done < "$catalog"

# clean up temporary files
rm "$catalog" "$san"

if [[ $invalid -gt 0 ]]; then
 echo "${invalid} legacy certificates were detected. Update your certificates to include a SAN
field."
 exit 1
```

```
else
 echo "All HTTPS certificates for this cloud are valid."
fi
```

2. Run the script.
3. Replace any certificates that the script reports as **INVALID** with certificates that contain SAN fields.

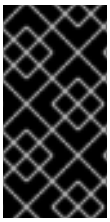
IMPORTANT

You must replace all legacy HTTPS certificates before you install OpenShift Container Platform 4.10 or update a cluster to that version. Legacy certificates will be rejected with the following message:

```
x509: certificate relies on legacy Common Name field, use SANs instead
```

19.1.3.1. Scanning RHOSP endpoints for legacy HTTPS certificates manually

Beginning with OpenShift Container Platform 4.10, HTTPS certificates must contain subject alternative name (SAN) fields. If you do not have access to the prerequisite tools that are listed in "Scanning RHOSP endpoints for legacy HTTPS certificates", perform the following steps to scan each HTTPS endpoint in a Red Hat OpenStack Platform (RHOSP) catalog for legacy certificates that only contain the **CommonName** field.



IMPORTANT

OpenShift Container Platform does not check the underlying RHOSP infrastructure for legacy certificates prior to installation or updates. Use the following steps to check for these certificates yourself. Failing to update legacy certificates prior to installing or updating a cluster will result in cluster dysfunction.

Procedure

1. On a command line, run the following command to view the URL of RHOSP public endpoints:

   ```
   $ openstack catalog list
   ```

   Record the URL for each HTTPS endpoint that the command returns.

2. For each public endpoint, note the host and the port.

   TIP

   Determine the host of an endpoint by removing the scheme, the port, and the path.

3. For each endpoint, run the following commands to extract the SAN field of the certificate:

   a. Set a **host** variable:

      ```
      $ host=<host_name>
      ```

   b. Set a **port** variable:

```
$ port=<port_number>
```

If the URL of the endpoint does not have a port, use the value **443**.

c. Retrieve the SAN field of the certificate:

```
$ openssl s_client -showcerts -servername "$host" -connect "$host:$port" </dev/null
2>/dev/null \
    | openssl x509 -noout -ext subjectAltName
```

Example output

```
X509v3 Subject Alternative Name:
    DNS:your.host.example.net
```

For each endpoint, look for output that resembles the previous example. If there is no output for an endpoint, the certificate of that endpoint is invalid and must be re-issued.

IMPORTANT

You must replace all legacy HTTPS certificates before you install OpenShift Container Platform 4.10 or update a cluster to that version. Legacy certificates are rejected with the following message:

```
x509: certificate relies on legacy Common Name field, use SANs instead
```

19.2. PREPARING TO INSTALL A CLUSTER THAT USES SR-IOV OR OVS-DPDK ON OPENSTACK

Before you install a OpenShift Container Platform cluster that uses single-root I/O virtualization (SR-IOV) or Open vSwitch with the Data Plane Development Kit (OVS-DPDK) on Red Hat OpenStack Platform (RHOSP), you must understand the requirements for each technology and then perform preparatory tasks.

19.2.1. Requirements for clusters on RHOSP that use either SR-IOV or OVS-DPDK

If you use SR-IOV or OVS-DPDK with your deployment, you must meet the following requirements:

- RHOSP compute nodes must use a flavor that supports huge pages.

19.2.1.1. Requirements for clusters on RHOSP that use SR-IOV

To use single-root I/O virtualization (SR-IOV) with your deployment, you must meet the following requirements:

- Plan your Red Hat OpenStack Platform (RHOSP) SR-IOV deployment .
- OpenShift Container Platform must support the NICs that you use. For a list of supported NICs, see "About Single Root I/O Virtualization (SR-IOV) hardware networks" in the "Hardware networks" subsection of the "Networking" documentation.
- For each node that will have an attached SR-IOV NIC, your RHOSP cluster must have:

- One instance from the RHOSP quota
- One port attached to the machines subnet
- One port for each SR-IOV Virtual Function
- A flavor with at least 16 GB memory, 4 vCPUs, and 25 GB storage space

- SR-IOV deployments often employ performance optimizations, such as dedicated or isolated CPUs. For maximum performance, configure your underlying RHOSP deployment to use these optimizations, and then run OpenShift Container Platform compute machines on the optimized infrastructure.
  - For more information about configuring performant RHOSP compute nodes, see Configuring Compute nodes for performance.

19.2.1.2. Requirements for clusters on RHOSP that use OVS-DPDK

To use Open vSwitch with the Data Plane Development Kit (OVS-DPDK) with your deployment, you must meet the following requirements:

- Plan your Red Hat OpenStack Platform (RHOSP) OVS-DPDK deployment by referring to Planning your OVS-DPDK deployment in the Network Functions Virtualization Planning and Configuration Guide.
- Configure your RHOSP OVS-DPDK deployment according to Configuring an OVS-DPDK deployment in the Network Functions Virtualization Planning and Configuration Guide.

19.2.2. Preparing to install a cluster that uses SR-IOV

You must configure RHOSP before you install a cluster that uses SR-IOV on it.

19.2.2.1. Creating SR-IOV networks for compute machines

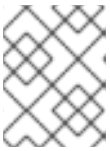
If your Red Hat OpenStack Platform (RHOSP) deployment supports single root I/O virtualization (SR-IOV), you can provision SR-IOV networks that compute machines run on.

NOTE

The following instructions entail creating an external flat network and an external, VLAN-based network that can be attached to a compute machine. Depending on your RHOSP deployment, other network types might be required.

Prerequisites

- Your cluster supports SR-IOV.



NOTE

If you are unsure about what your cluster supports, review the OpenShift Container Platform SR-IOV hardware networks documentation.

- You created radio and uplink provider networks as part of your RHOSP deployment. The names **radio** and **uplink** are used in all example commands to represent these networks.

Procedure

1. On a command line, create a radio RHOSP network:

```
$ openstack network create radio --provider-physical-network radio --provider-network-type
flat --external
```

2. Create an uplink RHOSP network:

```
$ openstack network create uplink --provider-physical-network uplink --provider-network-type
vlan --external
```

3. Create a subnet for the radio network:

```
$ openstack subnet create --network radio --subnet-range <radio_network_subnet_range>
radio
```

4. Create a subnet for the uplink network:

```
$ openstack subnet create --network uplink --subnet-range <uplink_network_subnet_range>
uplink
```

19.2.3. Preparing to install a cluster that uses OVS-DPDK

You must configure RHOSP before you install a cluster that uses SR-IOV on it.

- Complete Creating a flavor and deploying an instance for OVS-DPDK before you install a cluster on RHOSP.

After you perform preinstallation tasks, install your cluster by following the most relevant OpenShift Container Platform on RHOSP installation instructions. Then, perform the tasks under "Next steps" on this page.

19.2.4. Next steps

- For either type of deployment:
  - Configure the Node Tuning Operator with huge pages support .
- To complete SR-IOV configuration after you deploy your cluster:
  - Install the SR-IOV Operator.
  - Configure your SR-IOV network device .
  - Create SR-IOV compute machines.
- Consult the following references after you deploy your cluster to improve its performance:
  - A test pod template for clusters that use OVS-DPDK on OpenStack .
  - A test pod template for clusters that use SR-IOV on OpenStack .
  - A performance profile template for clusters that use OVS-DPDK on OpenStack .

19.3. INSTALLING A CLUSTER ON OPENSTACK WITH CUSTOMIZATIONS

In OpenShift Container Platform version 4.11, you can install a customized cluster on Red Hat OpenStack Platform (RHOSP). To customize the installation, modify parameters in the **install-config.yaml** before you install the cluster.

19.3.1. Prerequisites

- You reviewed details about the OpenShift Container Platform installation and update processes.
- You read the documentation on selecting a cluster installation method and preparing it for users.
- You verified that OpenShift Container Platform 4.11 is compatible with your RHOSP version by using the Supported platforms for OpenShift clusters section. You can also compare platform support across different versions by viewing the OpenShift Container Platform on RHOSP support matrix.
- You have a storage service installed in RHOSP, such as block storage (Cinder) or object storage (Swift). Object storage is the recommended storage technology for OpenShift Container Platform registry cluster deployment. For more information, see Optimizing storage.
- You understand performance and scalability practices for cluster scaling, control plane sizing, and etcd. For more information, see Recommended host practices.
- You have the metadata service enabled in RHOSP.

19.3.2. Resource guidelines for installing OpenShift Container Platform on RHOSP

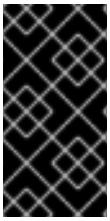
To support an OpenShift Container Platform installation, your Red Hat OpenStack Platform (RHOSP) quota must meet the following requirements:

Table 19.1. Recommended resources for a default OpenShift Container Platform cluster on RHOSP

Resource	Value
Floating IP addresses	3
Ports	15
Routers	1
Subnets	1
RAM	88 GB
vCPUs	22
Volume storage	275 GB

Resource	Value
Instances	7
Security groups	3
Security group rules	60
Server groups	2 - plus 1 for each additional availability zone in each machine pool

A cluster might function with fewer than recommended resources, but its performance is not guaranteed.



IMPORTANT

If RHOSP object storage (Swift) is available and operated by a user account with the **swiftoperator** role, it is used as the default backend for the OpenShift Container Platform image registry. In this case, the volume storage requirement is 175 GB. Swift space requirements vary depending on the size of the image registry.

NOTE

By default, your security group and security group rule quotas might be low. If you encounter problems, run **openstack quota set --secgroups 3 --secgroup-rules 60 <project>** as an administrator to increase them.

An OpenShift Container Platform deployment comprises control plane machines, compute machines, and a bootstrap machine.

19.3.2.1. Control plane machines

By default, the OpenShift Container Platform installation process creates three control plane machines.

Each machine requires:

- An instance from the RHOSP quota
- A port from the RHOSP quota
- A flavor with at least 16 GB memory and 4 vCPUs
- At least 100 GB storage space from the RHOSP quota

19.3.2.2. Compute machines

By default, the OpenShift Container Platform installation process creates three compute machines.

Each machine requires:

- An instance from the RHOSP quota

- A port from the RHOSP quota
- A flavor with at least 8 GB memory and 2 vCPUs
- At least 100 GB storage space from the RHOSP quota

TIP

Compute machines host the applications that you run on OpenShift Container Platform; aim to run as many as you can.

19.3.2.3. Bootstrap machine

During installation, a bootstrap machine is temporarily provisioned to stand up the control plane. After the production control plane is ready, the bootstrap machine is deprovisioned.

The bootstrap machine requires:

- An instance from the RHOSP quota
- A port from the RHOSP quota
- A flavor with at least 16 GB memory and 4 vCPUs
- At least 100 GB storage space from the RHOSP quota

19.3.3. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.11, you require access to the internet to install your cluster.

You must have internet access to:

- Access OpenShift Cluster Manager Hybrid Cloud Console to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access Quay.io to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.

IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

19.3.4. Enabling Swift on RHOSP

Swift is operated by a user account with the **swiftoperator** role. Add the role to an account before you run the installation program.

IMPORTANT

If the Red Hat OpenStack Platform (RHOSP) object storage service , commonly known as Swift, is available, OpenShift Container Platform uses it as the image registry storage. If it is unavailable, the installation program relies on the RHOSP block storage service, commonly known as Cinder.

If Swift is present and you want to use it, you must enable access to it. If it is not present, or if you do not want to use it, skip this section.

IMPORTANT

RHOSP 17 sets the **rgw_max_attr_size** parameter of Ceph RGW to 256 characters. This setting causes issues with uploading container images to the OpenShift Container Platform registry. You must set the value of **rgw_max_attr_size** to at least 1024 characters.

Before installation, check if your RHOSP deployment is affected by this problem. If it is, reconfigure Ceph RGW.

Prerequisites

- You have a RHOSP administrator account on the target environment.
- The Swift service is installed.
- On Ceph RGW, the **account in url** option is enabled.

Procedure

To enable Swift on RHOSP:

1. As an administrator in the RHOSP CLI, add the **swiftoperator** role to the account that will access Swift:

```
$ openstack role add --user <user> --project <project> swiftoperator
```

Your RHOSP deployment can now use Swift for the image registry.

19.3.5. Configuring an image registry with custom storage on clusters that run on RHOSP

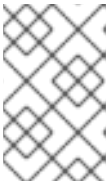
After you install a cluster on Red Hat OpenStack Platform (RHOSP), you can use a Cinder volume that is in a specific availability zone for registry storage.

Procedure

1. Create a YAML file that specifies the storage class and availability zone to use. For example:

```
apiVersion: storage.k8s.io/v1
kind: StorageClass
metadata:
  name: custom-csi-storageclass
provisioner: cinder.csi.openstack.org
volumeBindingMode: WaitForFirstConsumer
```

```
allowVolumeExpansion: true
parameters:
  availability: <availability_zone_name>
```



NOTE

OpenShift Container Platform does not verify the existence of the availability zone you choose. Verify the name of the availability zone before you apply the configuration.

2. From a command line, apply the configuration:

```
$ oc apply -f <storage_class_file_name>
```

Example output

```
storageclass.storage.k8s.io/custom-csi-storageclass created
```

3. Create a YAML file that specifies a persistent volume claim (PVC) that uses your storage class and the **openshift-image-registry** namespace. For example:

```
apiVersion: v1
kind: PersistentVolumeClaim
metadata:
  name: csi-pvc-imageregistry
  namespace: openshift-image-registry (1)
  annotations:
    imageregistry.openshift.io: "true"
spec:
  accessModes:
  - ReadWriteOnce
  volumeMode: Filesystem
  resources:
    requests:
      storage: 100Gi (2)
  storageClassName: <your_custom_storage_class> (3)
```

(1) Enter the namespace **openshift-image-registry**. This namespace allows the Cluster Image Registry Operator to consume the PVC.

(2) Optional: Adjust the volume size.

(3) Enter the name of the storage class that you created.

4. From a command line, apply the configuration:

```
$ oc apply -f <pvc_file_name>
```

Example output

```
persistentvolumeclaim/csi-pvc-imageregistry created
```

5. Replace the original persistent volume claim in the image registry configuration with the new claim:

```
$ oc patch configs.imageregistry.operator.openshift.io/cluster --type 'json' -p='[{"op":
"replace", "path": "/spec/storage/pvc/claim", "value": "csi-pvc-imageregistry"}]'
```

Example output

```
config.imageregistry.operator.openshift.io/cluster patched
```

Over the next several minutes, the configuration is updated.

Verification

To confirm that the registry is using the resources that you defined:

1. Verify that the PVC claim value is identical to the name that you provided in your PVC definition:

```
$ oc get configs.imageregistry.operator.openshift.io/cluster -o yaml
```

Example output

```
...
status:
    ...
    managementState: Managed
    pvc:
      claim: csi-pvc-imageregistry
...
```

2. Verify that the status of the PVC is **Bound**:

```
$ oc get pvc -n openshift-image-registry csi-pvc-imageregistry
```

Example output

```
NAME                    STATUS   VOLUME                                     CAPACITY   ACCESS MODES
STORAGECLASS            AGE
csi-pvc-imageregistry   Bound    pvc-72a8f9c9-f462-11e8-b6b6-fa163e18b7b5   100Gi
RWO            custom-csi-storageclass   11m
```

19.3.6. Verifying external network access

The OpenShift Container Platform installation process requires external network access. You must provide an external network value to it, or deployment fails. Before you begin the process, verify that a network with the external router type exists in Red Hat OpenStack Platform (RHOSP).

Prerequisites

- Configure OpenStack's networking service to have DHCP agents forward instances' DNS queries

Procedure

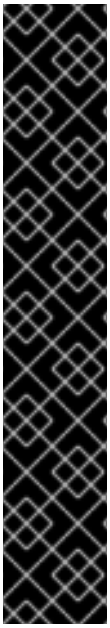
1. Using the RHOSP CLI, verify the name and ID of the 'External' network:

```
$ openstack network list --long -c ID -c Name -c "Router Type"
```

Example output

```
+--------------------------------------+---------------+-------------+
| ID                                   | Name          | Router Type |
+--------------------------------------+---------------+-------------+
| 148a8023-62a7-4672-b018-003462f8d7dc | public_network | External    |
+--------------------------------------+---------------+-------------+
```

A network with an external router type appears in the network list. If at least one does not, see Creating a default floating IP network and Creating a default provider network .



IMPORTANT

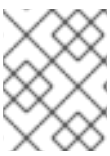
If the external network's CIDR range overlaps one of the default network ranges, you must change the matching network ranges in the **install-config.yaml** file before you start the installation process.

The default network ranges are:

Network	Range
machineNetwork	10.0.0.0/16
serviceNetwork	172.30.0.0/16
clusterNetwork	10.128.0.0/14

WARNING

If the installation program finds multiple networks with the same name, it sets one of them at random. To avoid this behavior, create unique names for resources in RHOSP.



NOTE

If the Neutron trunk service plugin is enabled, a trunk port is created by default. For more information, see Neutron trunk port .

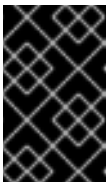
19.3.7. Defining parameters for the installation program

The OpenShift Container Platform installation program relies on a file that is called **clouds.yaml**. The file describes Red Hat OpenStack Platform (RHOSP) configuration parameters, including the project name, log in information, and authorization service URLs.

Procedure

1. Create the **clouds.yaml** file:

   - If your RHOSP distribution includes the Horizon web UI, generate a **clouds.yaml** file in it.

     IMPORTANT

     Remember to add a password to the **auth** field. You can also keep secrets in a separate file from **clouds.yaml**. OpenShift Container Platform does not support application credentials.

   - If your RHOSP distribution does not include the Horizon web UI, or you do not want to use Horizon, create the file yourself. For detailed information about **clouds.yaml**, see Config files in the RHOSP documentation.

     ```
     clouds:
       shiftstack:
         auth:
           auth_url: http://10.10.14.42:5000/v3
           project_name: shiftstack
           username: <username>
           password: <password>
           user_domain_name: Default
           project_domain_name: Default
       dev-env:
         region_name: RegionOne
         auth:
           username: <username>
           password: <password>
           project_name: 'devonly'
           auth_url: 'https://10.10.14.22:5001/v2.0'
     ```

2. If your RHOSP installation uses self-signed certificate authority (CA) certificates for endpoint authentication:

   a. Copy the certificate authority file to your machine.

   b. Add the **cacerts** key to the **clouds.yaml** file. The value must be an absolute, non-root-accessible path to the CA certificate:

     ```
     clouds:
       shiftstack:
         ...
         cacert: "/etc/pki/ca-trust/source/anchors/ca.crt.pem"
     ```

TIP

After you run the installer with a custom CA certificate, you can update the certificate by editing the value of the **ca-cert.pem** key in the **cloud-provider-config** keymap. On a command line, run:

```
$ oc edit configmap -n openshift-config cloud-provider-config
```

3. Place the **clouds.yaml** file in one of the following locations:
   a. The value of the **OS_CLIENT_CONFIG_FILE** environment variable
   b. The current directory
   c. A Unix-specific user configuration directory, for example **~/.config/openstack/clouds.yaml**
   d. A Unix-specific site configuration directory, for example **/etc/openstack/clouds.yaml**
   The installation program searches for **clouds.yaml** in that order.

19.3.8. Setting cloud provider options

Optionally, you can edit the cloud provider configuration for your cluster. The cloud provider configuration controls how OpenShift Container Platform interacts with Red Hat OpenStack Platform (RHOSP).

For a complete list of cloud provider configuration parameters, see the "OpenStack cloud configuration reference guide" page in the "Installing on OpenStack" documentation.

Procedure

1. If you have not already generated manifest files for your cluster, generate them by running the following command:

```
$ openshift-install --dir <destination_directory> create manifests
```

2. In a text editor, open the cloud-provider configuration manifest file. For example:

```
$ vi openshift/manifests/cloud-provider-config.yaml
```

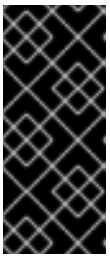
3. Modify the options based on the cloud configuration specification.
   Configuring Octavia for load balancing is a common case for clusters that do not use Kuryr. For example:

```
#...
[LoadBalancer]
use-octavia=true 1
lb-provider = "amphora" 2
floating-network-id="d3deb660-4190-40a3-91f1-37326fe6ec4a" 3
create-monitor = True 4
monitor-delay = 10s 5
monitor-timeout = 10s 6
monitor-max-retries = 1 7
#...
```

1. This property enables Octavia integration.
2. This property sets the Octavia provider that your load balancer uses. It accepts **"ovn"** or **"amphora"** as values. If you choose to use OVN, you must also set **lb-method** to **SOURCE_IP_PORT**.
3. This property is required if you want to use multiple external networks with your cluster. The cloud provider creates floating IP addresses on the network that is specified here.
4. This property controls whether the cloud provider creates health monitors for Octavia load balancers. Set the value to **True** to create health monitors. As of RHOSP 16.1 and 16.2, this feature is only available for the Amphora provider.
5. This property sets the frequency with which endpoints are monitored. The value must be in the **time.ParseDuration()** format. This property is required if the value of the **create-monitor** property is **True**.
6. This property sets the time that monitoring requests are open before timing out. The value must be in the **time.ParseDuration()** format. This property is required if the value of the **create-monitor** property is **True**.
7. This property defines how many successful monitoring requests are required before a load balancer is marked as online. The value must be an integer. This property is required if the value of the **create-monitor** property is **True**.

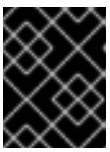
IMPORTANT

Prior to saving your changes, verify that the file is structured correctly. Clusters might fail if properties are not placed in the appropriate section.



IMPORTANT

You must set the value of the **create-monitor** property to **True** if you use services that have the value of the **.spec.externalTrafficPolicy** property set to **Local**. The OVN Octavia provider in RHOSP 16.1 and 16.2 does not support health monitors. Therefore, services that have **ETP** parameter values set to **Local** might not respond when the **lb-provider** value is set to **"ovn"**.



IMPORTANT

For installations that use Kuryr, Kuryr handles relevant services. There is no need to configure Octavia load balancing in the cloud provider.

4. Save the changes to the file and proceed with installation.

TIP

You can update your cloud provider configuration after you run the installer. On a command line, run:

```
$ oc edit configmap -n openshift-config cloud-provider-config
```

After you save your changes, your cluster will take some time to reconfigure itself. The process is complete if none of your nodes have a **SchedulingDisabled** status.

19.3.8.1. External load balancers that use pre-defined floating IP addresses

Commonly, Red Hat OpenStack Platform (RHOSP) deployments disallow non-administrator users from creating specific floating IP addresses. If such a policy is in place and you use a floating IP address in your service specification, the cloud provider will fail to handle IP address assignment to load balancers.

If you use an external cloud provider, you can avoid this problem by pre-creating a floating IP address and specifying it in your service specification. The in-tree cloud provider does not support this method.

Alternatively, you can modify the RHOSP Networking service (Neutron) to allow non-administrator users to create specific floating IP addresses.

Additional resources

- For more information about cloud provider configuration, see OpenStack cloud provider options.

19.3.9. Obtaining the installation program

Before you install OpenShift Container Platform, download the installation file on a local computer.

Prerequisites

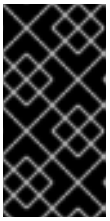
- You have a computer that runs Linux or macOS, with 500 MB of local disk space.

Procedure

1. Access the Infrastructure Provider page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program that corresponds with your host operating system and architecture, and place the file in the directory where you will store the installation configuration files.

IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.



IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation pull secret from the Red Hat OpenShift Cluster Manager . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

19.3.10. Creating the installation configuration file

You can customize the OpenShift Container Platform cluster you install on Red Hat OpenStack Platform (RHOSP).

Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.
- Obtain service principal permissions at the subscription level.

Procedure

1. Create the **install-config.yaml** file.
   a. Change to the directory that contains the installation program and run the following command:

```
$ ./openshift-install create install-config --dir <installation_directory> 1
```

   1 For **<installation_directory>**, specify the directory name to store the files that the installation program creates.

   When specifying the directory:

   - Verify that the directory has the **execute** permission. This permission is required to run Terraform binaries under the installation directory.
   - Use an empty directory. Some installation assets, such as bootstrap X.509 certificates, have short expiration intervals, therefore you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

   b. At the prompts, provide the configuration details for your cloud:

i. Optional: Select an SSH key to use to access your cluster machines.

NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

ii. Select **openstack** as the platform to target.

iii. Specify the Red Hat OpenStack Platform (RHOSP) external network name to use for installing the cluster.

iv. Specify the floating IP address to use for external access to the OpenShift API.

v. Specify a RHOSP flavor with at least 16 GB RAM to use for control plane nodes and 8 GB RAM for compute nodes.

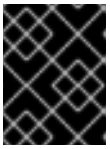
vi. Select the base domain to deploy the cluster to. All DNS records will be sub-domains of this base and will also include the cluster name.

vii. Enter a name for your cluster. The name must be 14 or fewer characters long.

viii. Paste the pull secret from the Red Hat OpenShift Cluster Manager .

2. Modify the **install-config.yaml** file. You can find more information about the available parameters in the "Installation configuration parameters" section.

3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.



IMPORTANT

The **install-config.yaml** file is consumed during the installation process. If you want to reuse the file, you must back it up now.

Additional resources

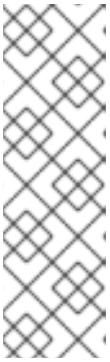
See Installation configuration parameters section for more information about the available parameters.

19.3.10.1. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.



NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
```

1. A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
2. A proxy URL to use for creating HTTPS connections outside the cluster.
3. A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use ***** to bypass the proxy for all destinations.
4. If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace that contains one or more additional CA certificates that are required for proxying HTTPS connections. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges these contents with the Red Hat Enterprise Linux CoreOS (RHCOS) trust bundle, and this config map is referenced in the **trustedCA** field of the **Proxy** object. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.

NOTE

The installation program does not support the proxy **readinessEndpoints** field.

NOTE

If the installer times out, restart and then complete the deployment by using the **wait-for** command of the installer. For example:

```
$ ./openshift-install wait-for install-complete --log-level debug
```

2. Save the file and reference it when installing OpenShift Container Platform.

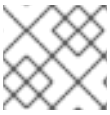
The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.

NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

19.3.11. Installation configuration parameters

Before you deploy an OpenShift Container Platform cluster, you provide parameter values to describe your account on the cloud platform that hosts your cluster and optionally customize your cluster's platform. When you create the **install-config.yaml** installation configuration file, you provide values for the required parameters through the command line. If you customize your cluster, you can modify the **install-config.yaml** file to provide more details about the platform.



NOTE

After installation, you cannot modify these parameters in the **install-config.yaml** file.

19.3.11.1. Required configuration parameters

Required installation configuration parameters are described in the following table:

Table 19.2. Required parameters

Parameter	Description	Values
apiVersion	The API version for the **install-config.yaml** content. The current version is **v1**. The installer may also support older API versions.	String

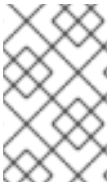
Parameter	Description	Values
baseDomain	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the **baseDomain** and **metadata.name** parameter values that uses the **<metadata.name>.<baseDomain>** format.	A fully-qualified domain or subdomain name, such as **example.com**.
metadata	Kubernetes resource **ObjectMeta**, from which only the **name** parameter is consumed.	Object
metadata.name	The name of the cluster. DNS records for the cluster are all subdomains of **{{.metadata.name}}.{{.baseDomain}}**.	String of lowercase letters, hyphens (**-**), and periods (**.**), such as **dev**. The string must be 14 characters or fewer long.
platform	The configuration for the specific platform upon which to perform the installation: **alibabacloud**, **aws**, **baremetal**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**. For additional information about **platform.<platform>** parameters, consult the table for your specific platform that follows.	Object

Parameter	Description	Values
pullSecret	Get a pull secret from the Red Hat OpenShift Cluster Manager to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	<pre>{ "auths":{ "cloud.openshift.com":{ "auth":"b3Blb=", "email":"you@example.com" }, "quay.io":{ "auth":"b3Blb=", "email":"you@example.com" } } }</pre>

19.3.11.2. Network configuration parameters

You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

Only IPv4 addresses are supported.



NOTE

Globalnet is not supported with Red Hat OpenShift Data Foundation disaster recovery solutions. For regional disaster recovery scenarios, ensure that you use a nonoverlapping range of private IP addresses for the cluster and service networks in each cluster.

Table 19.3. Network parameters

Parameter	Description	Values
networking	The configuration for the cluster network.	Object  **NOTE** You cannot modify parameters specified by the **networking** object after installation.

Parameter	Description	Values
networking.networkType	The cluster network provider Container Network Interface (CNI) cluster network provider to install.	Either **OpenShiftSDN** or **OVNKubernetes**. **OpenShiftSDN** is a CNI provider for all-Linux networks. **OVNKubernetes** is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is **OpenShiftSDN**.
networking.clusterNetwork	The IP address blocks for pods. The default value is **10.128.0.0/14** with a host prefix of **/23**. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: `networking:` `  clusterNetwork:` `  - cidr: 10.128.0.0/14` `  hostPrefix: 23`
networking.clusterNetwork.cidr	Required if you use **networking.clusterNetwork**. An IP address block. An IPv4 network.	An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between **0** and **32**.
networking.clusterNetwork.hostPrefix	The subnet prefix length to assign to each individual node. For example, if **hostPrefix** is set to **23** then each node is assigned a **/23** subnet out of the given **cidr**. A **hostPrefix** value of **23** provides 510 (2^(32 - 23) - 2) pod IP addresses.	A subnet prefix. The default value is **23**.
networking.serviceNetwork	The IP address block for services. The default value is **172.30.0.0/16**. The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.	An array with an IP address block in CIDR format. For example: `networking:` `  serviceNetwork:` `  - 172.30.0.0/16`
networking.machineNetwork	The IP address blocks for machines. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: `networking:` `  machineNetwork:` `  - cidr: 10.0.0.0/16`

Parameter	Description	Values
networking.machineNetwork.cidr	Required if you use **networking.machineNetwork**. An IP address block. The default value is **10.0.0.0/16** for all platforms other than libvirt. For libvirt, the default value is **192.168.126.0/24**.	An IP network block in CIDR notation. For example, **10.0.0.0/16**.  **NOTE** Set the **networking.machineNetwork** to match the CIDR that the preferred NIC resides in.

19.3.11.3. Optional configuration parameters

Optional installation configuration parameters are described in the following table:

Table 19.4. Optional parameters

Parameter	Description	Values
additionalTrustBundle	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String
capabilities	Controls the installation of optional core cluster components. You can reduce the footprint of your OpenShift Container Platform cluster by disabling optional components.	String array
capabilities.baselineCapabilitySet	Selects an initial set of optional capabilities to enable. Valid values are **None**, **v4.11** and **vCurrent**. **v4.11** enables the **baremetal** Operator, the **marketplace** Operator, and the **openshift-samples** content. **vCurrent** installs the recommended set of capabilities for the current version of OpenShift Container Platform. The default value is **vCurrent**.	String

Parameter	Description	Values
capabilities.additionalEnabledCapabilities	Extends the set of optional capabilities beyond what you specify in **baselineCapabilitySet**. Valid values are **baremetal**, **marketplace** and **openshift-samples**. You may specify multiple capabilities in this parameter.	String array
cgroupsV2	Enables Linux control groups version 2 (cgroups v2) on specific nodes in your cluster. The OpenShift Container Platform process for enabling cgroups v2 disables all cgroup version 1 controllers and hierarchies. The OpenShift Container Platform cgroups version 2 feature is in Developer Preview and is not supported by Red Hat at this time.	**true**
compute	The configuration for the machines that comprise the compute nodes.	Array of **MachinePool** objects.
compute.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** (the default).	String
compute.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  IMPORTANT If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
compute.name	Required if you use **compute**. The name of the machine pool.	**worker**

Parameter	Description	Values
compute.platform	Required if you use **compute**. Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the **controlPlane.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
compute.replicas	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to **2**. The default value is **3**.
controlPlane	The configuration for the machines that comprise the control plane.	Array of **MachinePool** objects.
controlPlane.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** (the default).	String
controlPlane.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  IMPORTANT If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
controlPlane.name	Required if you use **controlPlane**. The name of the machine pool.	**master**

Parameter	Description	Values
controlPlane.platform	Required if you use **controlPlane**. Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the **compute.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
controlPlane.replicas	The number of control plane machines to provision.	The only supported value is **3**, which is the default value.
credentialsMode	The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported.  **NOTE** Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the *Cloud Credential Operator* entry in the *Cluster Operators reference* content.  **NOTE** If your AWS account has service control policies (SCP) enabled, you must configure the **credentialsMode** parameter to **Mint**, **Passthrough** or **Manual**.	**Mint**, **Passthrough**, **Manual** or an empty string (**""**).

Parameter	Description	Values
fips	Enable or disable FIPS mode. The default is **false** (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.  **IMPORTANT** To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.  **NOTE** If you are using Azure File storage, you cannot enable FIPS mode.	**false** or **true**
imageContentSources	Sources and repositories for the release-image content.	Array of objects. Includes a **source** and, optionally, **mirrors**, as described in the following rows of this table.
imageContentSources.source	Required if you use **imageContentSources**. Specify the repository that users refer to, for example, in image pull specifications.	String

Parameter	Description	Values
imageContentSources.mirrors	Specify one or more repositories that may also contain the same images.	Array of strings
publish	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	**Internal** or **External**. The default value is **External**. Setting this field to **Internal** is not supported on non-cloud platforms and IBM Cloud VPC.  **IMPORTANT** If the value of the field is set to **Internal**, the cluster will become non-functional. For more information, refer to BZ#1953035.
sshKey	The SSH key to authenticate access to your cluster machines.  **NOTE** For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.	For example, **sshKey: ssh-ed25519 AAAA..**.

19.3.11.4. Additional Red Hat OpenStack Platform (RHOSP) configuration parameters

Additional RHOSP configuration parameters are described in the following table:

Table 19.5. Additional RHOSP parameters

Parameter	Description	Values
compute.platform.openstack.rootVolume.size	For compute machines, the size in gigabytes of the root volume. If you do not set this value, machines use ephemeral storage.	Integer, for example **30**.

Parameter	Description	Values
compute.platform.openstack.rootVolume.type	For compute machines, the root volume's type.	String, for example **performance**.
controlPlane.platform.openstack.rootVolume.size	For control plane machines, the size in gigabytes of the root volume. If you do not set this value, machines use ephemeral storage.	Integer, for example **30**.
controlPlane.platform.openstack.rootVolume.type	For control plane machines, the root volume's type.	String, for example **performance**.
platform.openstack.cloud	The name of the RHOSP cloud to use from the list of clouds in the **clouds.yaml** file.	String, for example **MyCloud**.
platform.openstack.externalNetwork	The RHOSP external network name to be used for installation.	String, for example **external**.
platform.openstack.computeFlavor	The RHOSP flavor to use for control plane and compute machines. This property is deprecated. To use a flavor as the default for all machine pools, add it as the value of the **type** key in the **platform.openstack.defaultMachinePlatform** property. You can also set a flavor value for each machine pool individually.	String, for example **m1.xlarge**.

19.3.11.5. Optional RHOSP configuration parameters

Optional RHOSP configuration parameters are described in the following table:

Table 19.6. Optional RHOSP parameters

Parameter	Description	Values
compute.platform.openstack.additionalNetworkIDs	Additional networks that are associated with compute machines. Allowed address pairs are not created for additional networks.	A list of one or more UUIDs as strings. For example, **fa806b2f-ac49-4bce-b9db-124bc64209bf**.
compute.platform.openstack.additionalSecurityGroupIDs	Additional security groups that are associated with compute machines.	A list of one or more UUIDs as strings. For example, **7ee219f3-d2e9-48a1-96c2-e7429f1b0da7**.
compute.platform.openstack.zones	RHOSP Compute (Nova) availability zones (AZs) to install machines on. If this parameter is not set, the installer relies on the default settings for Nova that the RHOSP administrator configured. On clusters that use Kuryr, RHOSP Octavia does not support availability zones. Load balancers and, if you are using the Amphora provider driver, OpenShift Container Platform services that rely on Amphora VMs, are not created according to the value of this property.	A list of strings. For example, **["zone-1", "zone-2"]**.
compute.platform.openstack.rootVolume.zones	For compute machines, the availability zone to install root volumes on. If you do not set a value for this parameter, the installer selects the default availability zone.	A list of strings, for example **["zone-1", "zone-2"]**.

Parameter	Description	Values
compute.platform.openstack.serverGroupPolicy	Server group policy to apply to the group that will contain the compute machines in the pool. You cannot change server group policies or affiliations after creation. Supported options include **anti-affinity**, **soft-affinity**, and **soft-anti-affinity**. The default value is **soft-anti-affinity**. An **affinity** policy prevents migrations and therefore affects RHOSP upgrades. The **affinity** policy is not supported. If you use a strict **anti-affinity** policy, an additional RHOSP host is required during instance migration.	A server group policy to apply to the machine pool. For example, **soft-affinity**.
controlPlane.platform.openstack.additionalNetworkIDs	Additional networks that are associated with control plane machines. Allowed address pairs are not created for additional networks.	A list of one or more UUIDs as strings. For example, **fa806b2f-ac49-4bce-b9db-124bc64209bf**.
controlPlane.platform.openstack.additionalSecurityGroupIDs	Additional security groups that are associated with control plane machines.	A list of one or more UUIDs as strings. For example, **7ee219f3-d2e9-48a1-96c2-e7429f1b0da7**.

Parameter	Description	Values
controlPlane.platform.openstack.zones	RHOSP Compute (Nova) availability zones (AZs) to install machines on. If this parameter is not set, the installer relies on the default settings for Nova that the RHOSP administrator configured. On clusters that use Kuryr, RHOSP Octavia does not support availability zones. Load balancers and, if you are using the Amphora provider driver, OpenShift Container Platform services that rely on Amphora VMs, are not created according to the value of this property.	A list of strings. For example, **["zone-1", "zone-2"]**.
controlPlane.platform.openstack.rootVolume.zones	For control plane machines, the availability zone to install root volumes on. If you do not set this value, the installer selects the default availability zone.	A list of strings, for example **["zone-1", "zone-2"]**.
controlPlane.platform.openstack.serverGroupPolicy	Server group policy to apply to the group that will contain the control plane machines in the pool. You cannot change server group policies or affiliations after creation. Supported options include **anti-affinity**, **soft-affinity**, and **soft-anti-affinity**. The default value is **soft-anti-affinity**. An **affinity** policy prevents migrations, and therefore affects RHOSP upgrades. The **affinity** policy is not supported. If you use a strict **anti-affinity** policy, an additional RHOSP host is required during instance migration.	A server group policy to apply to the machine pool. For example, **soft-affinity**.

Parameter	Description	Values
platform.openstack.clusterOSImage	The location from which the installer downloads the RHCOS image. You must set this parameter to perform an installation in a restricted network.	An HTTP or HTTPS URL, optionally with an SHA-256 checksum. For example, **http://mirror.example.com/images/rhcos-43.81.201912131630.0-openstack.x86_64.qcow2.gz?sha256=ffebbd68e8a1f2a245ca19522c16c86f67f9ac8e4e0c1f0a812b068b16f7265d**. The value can also be the name of an existing Glance image, for example **my-rhcos**.
platform.openstack.clusterOSImageProperties	Properties to add to the installer-uploaded ClusterOSImage in Glance. This property is ignored if **platform.openstack.clusterOSImage** is set to an existing Glance image. You can use this property to exceed the default persistent volume (PV) limit for RHOSP of 26 PVs per node. To exceed the limit, set the **hw_scsi_model** property value to **virtio-scsi** and the **hw_disk_bus** value to **scsi**. You can also use this property to enable the QEMU guest agent by including the **hw_qemu_guest_agent** property with a value of **yes**.	A list of key-value string pairs. For example, **["hw_scsi_model": "virtio-scsi", "hw_disk_bus": "scsi"]**.
platform.openstack.defaultMachinePlatform	The default machine pool platform configuration.	<pre>{ "type": "ml.large", "rootVolume": { "size": 30, "type": "performance" } }</pre>
platform.openstack.ingressFloatingIP	An existing floating IP address to associate with the Ingress port. To use this property, you must also define the **platform.openstack.externalNetwork** property.	An IP address, for example **128.0.0.1**.

Parameter	Description	Values
platform.openstack.apiFloatingIP	An existing floating IP address to associate with the API load balancer. To use this property, you must also define the **platform.openstack.externalNetwork** property.	An IP address, for example **128.0.0.1**.
platform.openstack.externalDNS	IP addresses for external DNS servers that cluster instances use for DNS resolution.	A list of IP addresses as strings. For example, **["8.8.8.8", "192.168.1.12"]**.
platform.openstack.machinesSubnet	The UUID of a RHOSP subnet that the cluster's nodes use. Nodes and virtual IP (VIP) ports are created on this subnet. The first item in **networking.machineNetwork** must match the value of **machinesSubnet**. If you deploy to a custom subnet, you cannot specify an external DNS server to the OpenShift Container Platform installer. Instead, add DNS to the subnet in RHOSP.	A UUID as a string. For example, **fa806b2f-ac49-4bce-b9db-124bc64209bf**.

19.3.11.6. Custom subnets in RHOSP deployments

Optionally, you can deploy a cluster on a Red Hat OpenStack Platform (RHOSP) subnet of your choice. The subnet's GUID is passed as the value of **platform.openstack.machinesSubnet** in the **install-config.yaml** file.

This subnet is used as the cluster's primary subnet. By default, nodes and ports are created on it. You can create nodes and ports on a different RHOSP subnet by setting the value of the **platform.openstack.machinesSubnet** property to the subnet's UUID.

Before you run the OpenShift Container Platform installer with a custom subnet, verify that your configuration meets the following requirements:

- The subnet that is used by **platform.openstack.machinesSubnet** has DHCP enabled.
- The CIDR of **platform.openstack.machinesSubnet** matches the CIDR of **networking.machineNetwork**.
- The installation program user has permission to create ports on this network, including ports with fixed IP addresses.

Clusters that use custom subnets have the following limitations:

- If you plan to install a cluster that uses floating IP addresses, the **platform.openstack.machinesSubnet** subnet must be attached to a router that is connected to the **externalNetwork** network.
- If the **platform.openstack.machinesSubnet** value is set in the **install-config.yaml** file, the installation program does not create a private network or subnet for your RHOSP machines.
- You cannot use the **platform.openstack.externalDNS** property at the same time as a custom subnet. To add DNS to a cluster that uses a custom subnet, configure DNS on the RHOSP network.

NOTE

By default, the API VIP takes x.x.x.5 and the Ingress VIP takes x.x.x.7 from your network's CIDR block. To override these default values, set values for **platform.openstack.apiVIP** and **platform.openstack.ingressVIP** that are outside of the DHCP allocation pool.

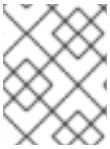
IMPORTANT

The CIDR ranges for networks are not adjustable after cluster installation. Red Hat does not provide direct guidance on determining the range during cluster installation because it requires careful consideration of the number of created pods per namespace.

19.3.11.7. Deploying a cluster with bare metal machines

If you want your cluster to use bare metal machines, modify the **install-config.yaml** file. Your cluster can have both control plane and compute machines running on bare metal, or just compute machines.

Bare-metal compute machines are not supported on clusters that use Kuryr.



NOTE

Be sure that your **install-config.yaml** file reflects whether the RHOSP network that you use for bare metal workers supports floating IP addresses or not.

Prerequisites

- The RHOSP Bare Metal service (Ironic) is enabled and accessible via the RHOSP Compute API.
- Bare metal is available as a RHOSP flavor.
- If your cluster runs on an RHOSP version that is more than 16.1.6 and less than 16.2.4, bare metal workers do not function due to a known issue that causes the metadata service to be unavailable for services on OpenShift Container Platform nodes.
- The RHOSP network supports both VM and bare metal server attachment.
- Your network configuration does not rely on a provider network. Provider networks are not supported.
- If you want to deploy the machines on a pre-existing network, a RHOSP subnet is provisioned.
- If you want to deploy the machines on an installer-provisioned network, the RHOSP Bare Metal service (Ironic) is able to listen for and interact with Preboot eXecution Environment (PXE) boot machines that run on tenant networks.

- You created an **install-config.yaml** file as part of the OpenShift Container Platform installation process.

Procedure

1. In the **install-config.yaml** file, edit the flavors for machines:

   a. If you want to use bare-metal control plane machines, change the value of **controlPlane.platform.openstack.type** to a bare metal flavor.

   b. Change the value of **compute.platform.openstack.type** to a bare metal flavor.

   c. If you want to deploy your machines on a pre-existing network, change the value of **platform.openstack.machinesSubnet** to the RHOSP subnet UUID of the network. Control plane and compute machines must use the same subnet.

   An example bare metal install-config.yaml file

```
controlPlane:
  platform:
    openstack:
      type: <bare_metal_control_plane_flavor> 1
...

compute:
 - architecture: amd64
   hyperthreading: Enabled
   name: worker
   platform:
     openstack:
       type: <bare_metal_compute_flavor> 2
   replicas: 3
...

platform:
  openstack:
    machinesSubnet: <subnet_UUID> 3
...
```

   1. If you want to have bare-metal control plane machines, change this value to a bare metal flavor.
   2. Change this value to a bare metal flavor to use for compute machines.
   3. If you want to use a pre-existing network, change this value to the UUID of the RHOSP subnet.

Use the updated **install-config.yaml** file to complete the installation process. The compute machines that are created during deployment use the flavor that you added to the file.

NOTE

The installer may time out while waiting for bare metal machines to boot.

If the installer times out, restart and then complete the deployment by using the **wait-for** command of the installer. For example:

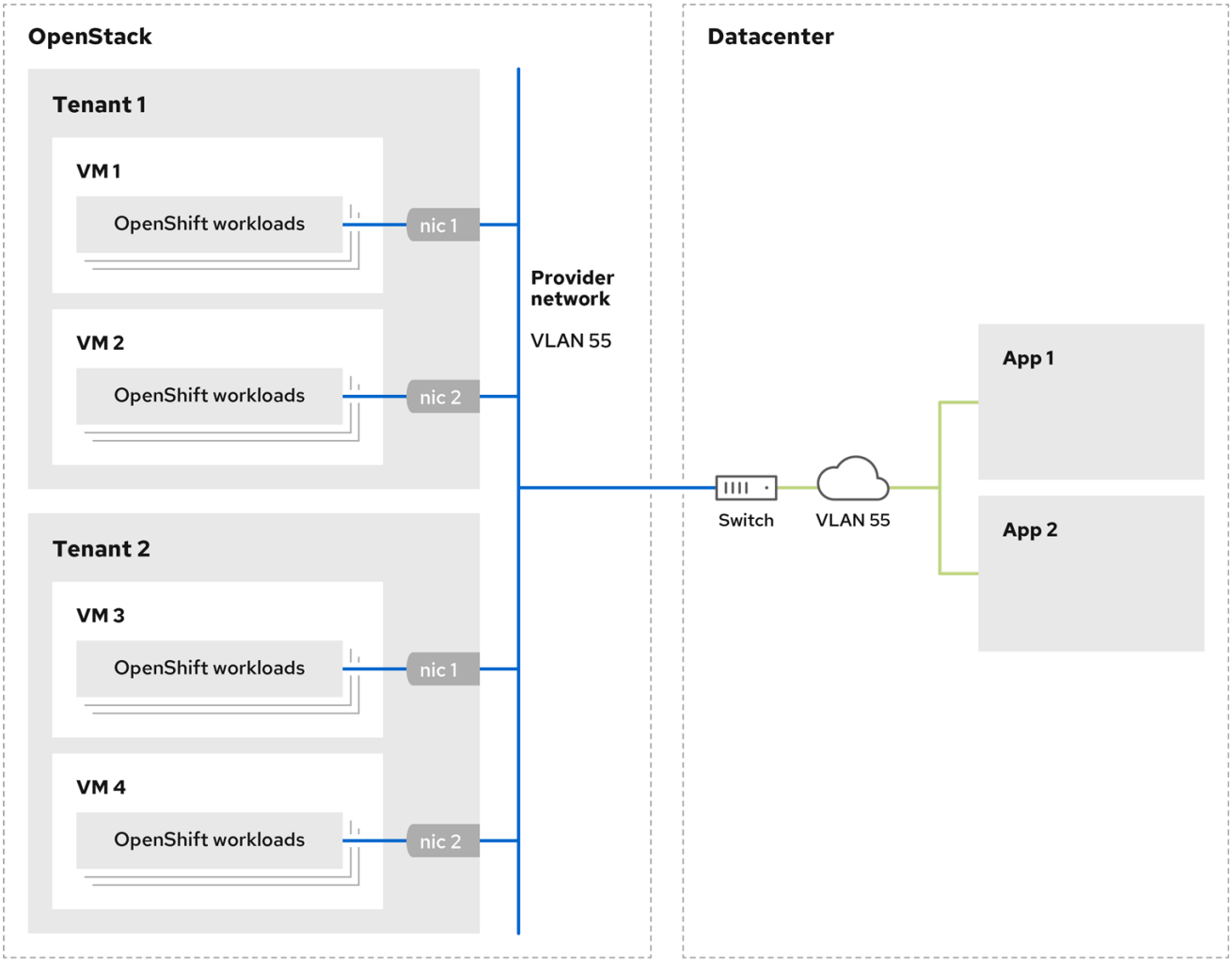
```
$ ./openshift-install wait-for install-complete --log-level debug
```

19.3.11.8. Cluster deployment on RHOSP provider networks

You can deploy your OpenShift Container Platform clusters on Red Hat OpenStack Platform (RHOSP) with a primary network interface on a provider network. Provider networks are commonly used to give projects direct access to a public network that can be used to reach the internet. You can also share provider networks among projects as part of the network creation process.

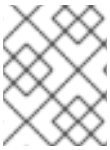
RHOSP provider networks map directly to an existing physical network in the data center. A RHOSP administrator must create them.

In the following example, OpenShift Container Platform workloads are connected to a data center by using a provider network:



OpenShift Container Platform clusters that are installed on provider networks do not require tenant networks or floating IP addresses. The installer does not create these resources during installation.

Example provider network types include flat (untagged) and VLAN (802.1Q tagged).



NOTE

A cluster can support as many provider network connections as the network type allows. For example, VLAN networks typically support up to 4096 connections.

You can learn more about provider and tenant networks in the RHOSP documentation.

19.3.11.8.1. RHOSP provider network requirements for cluster installation

Before you install an OpenShift Container Platform cluster, your Red Hat OpenStack Platform (RHOSP) deployment and provider network must meet a number of conditions:

- The RHOSP networking service (Neutron) is enabled and accessible through the RHOSP networking API.
- The RHOSP networking service has the port security and allowed address pairs extensions enabled.
- The provider network can be shared with other tenants.

  TIP

  Use the **openstack network create** command with the **--share** flag to create a network that can be shared.

- The RHOSP project that you use to install the cluster must own the provider network, as well as an appropriate subnet.

  TIP

  To create a network for a project that is named "openshift," enter the following command

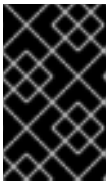
  ```
  $ openstack network create --project openshift
  ```

  To create a subnet for a project that is named "openshift," enter the following command

  ```
  $ openstack subnet create --project openshift
  ```

  To learn more about creating networks on RHOSP, read the provider networks documentation.

  If the cluster is owned by the **admin** user, you must run the installer as that user to create ports on the network.



IMPORTANT

Provider networks must be owned by the RHOSP project that is used to create the cluster. If they are not, the RHOSP Compute service (Nova) cannot request a port from that network.

- Verify that the provider network can reach the RHOSP metadata service IP address, which is **169.254.169.254** by default.
  Depending on your RHOSP SDN and networking service configuration, you might need to provide the route when you create the subnet. For example:

```
$ openstack subnet create --dhcp --host-route
destination=169.254.169.254/32,gateway=192.0.2.2 ...
```

- Optional: To secure the network, create role-based access control (RBAC) rules that limit network access to a single project.

19.3.11.8.2. Deploying a cluster that has a primary interface on a provider network

You can deploy an OpenShift Container Platform cluster that has its primary network interface on an Red Hat OpenStack Platform (RHOSP) provider network.

Prerequisites

- Your Red Hat OpenStack Platform (RHOSP) deployment is configured as described by "RHOSP provider network requirements for cluster installation".

Procedure

1. In a text editor, open the **install-config.yaml** file.
2. Set the value of the **platform.openstack.apiVIP** property to the IP address for the API VIP.
3. Set the value of the **platform.openstack.ingressVIP** property to the IP address for the Ingress VIP.
4. Set the value of the **platform.openstack.machinesSubnet** property to the UUID of the provider network subnet.
5. Set the value of the **networking.machineNetwork.cidr** property to the CIDR block of the provider network subnet.

IMPORTANT

The **platform.openstack.apiVIP** and **platform.openstack.ingressVIP** properties must both be unassigned IP addresses from the **networking.machineNetwork.cidr** block.

Section of an installation configuration file for a cluster that relies on a RHOSP provider network

```
...
platform:
  openstack:
    apiVIP: 192.0.2.13
```

```
    ingressVIP: 192.0.2.23
    machinesSubnet: fa806b2f-ac49-4bce-b9db-124bc64209bf
    # ...
networking:
  machineNetwork:
  - cidr: 192.0.2.0/24
```

WARNING

You cannot set the **platform.openstack.externalNetwork** or **platform.openstack.externalDNS** parameters while using a provider network for the primary network interface.

When you deploy the cluster, the installer uses the **install-config.yaml** file to deploy the cluster on the provider network.

TIP

You can add additional networks, including provider networks, to the **platform.openstack.additionalNetworkIDs** list.

After you deploy your cluster, you can attach pods to additional networks. For more information, see Understanding multiple networks.

19.3.11.9. Sample customized install-config.yaml file for RHOSP

This sample **install-config.yaml** demonstrates all of the possible Red Hat OpenStack Platform (RHOSP) customization options.

IMPORTANT

This sample file is provided for reference only. You must obtain your **install-config.yaml** file by using the installation program.

```
apiVersion: v1
baseDomain: example.com
controlPlane:
  name: master
  platform: {}
  replicas: 3
compute:
- name: worker
  platform:
    openstack:
      type: ml.large
  replicas: 3
metadata:
  name: example
networking:
```

```
  clusterNetwork:
  - cidr: 10.128.0.0/14
    hostPrefix: 23
  machineNetwork:
  - cidr: 10.0.0.0/16
  serviceNetwork:
  - 172.30.0.0/16
  networkType: OpenShiftSDN
platform:
  openstack:
    cloud: mycloud
    externalNetwork: external
    computeFlavor: m1.xlarge
    apiFloatingIP: 128.0.0.1
fips: false
pullSecret: '{"auths": ...}'
sshKey: ssh-ed25519 AAAA...
```

19.3.12. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the ~/**.ssh/authorized_keys** list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The **./openshift-install gather** command also requires the SSH public key to be in place on the cluster nodes.

IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.

Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N '' -f <path>/<file_name> 1
```

1 Specify the path and file name, such as ~/**.ssh/id_ed25519**, of the new SSH key. If you have an existing key pair, ensure your public key is in the your ~/**.ssh** directory.

NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS validated or Modules In Process cryptographic libraries on the **x86_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the ~/**.ssh/id_ed25519.pub** public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the **./openshift-install gather** command.

NOTE

On some distributions, default SSH private key identities such as ~/**.ssh/id_rsa** and ~/**.ssh/id_dsa** are managed automatically.

a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

Example output

```
Agent pid 31874
```

NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

1 Specify the path and file name for your SSH private key, such as ~/**.ssh/id_ed25519**

Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

19.3.13. Enabling access to the environment

At deployment, all OpenShift Container Platform machines are created in a Red Hat OpenStack Platform (RHOSP)-tenant network. Therefore, they are not accessible directly in most RHOSP deployments.

You can configure OpenShift Container Platform API and application access by using floating IP addresses (FIPs) during installation. You can also complete an installation without configuring FIPs, but the installer will not configure a way to reach the API or applications externally.

19.3.13.1. Enabling access with floating IP addresses

Create floating IP (FIP) addresses for external access to the OpenShift Container Platform API and cluster applications.

Procedure

1. Using the Red Hat OpenStack Platform (RHOSP) CLI, create the API FIP:

```
$ openstack floating ip create --description "API <cluster_name>.<base_domain>"
<external_network>
```

2. Using the Red Hat OpenStack Platform (RHOSP) CLI, create the apps, or Ingress, FIP:

```
$ openstack floating ip create --description "Ingress <cluster_name>.<base_domain>"
<external_network>
```

3. Add records that follow these patterns to your DNS server for the API and Ingress FIPs:

```
api.<cluster_name>.<base_domain>.  IN  A  <API_FIP>
*.apps.<cluster_name>.<base_domain>. IN  A <apps_FIP>
```

NOTE

If you do not control the DNS server, you can access the cluster by adding the cluster domain names such as the following to your **/etc/hosts** file:

- **<api_floating_ip> api.<cluster_name>.<base_domain>**
- **<application_floating_ip> grafana-openshift-monitoring.apps.<cluster_name>.<base_domain>**
- **<application_floating_ip> prometheus-k8s-openshift-monitoring.apps.<cluster_name>.<base_domain>**
- **<application_floating_ip> oauth-openshift.apps.<cluster_name>.<base_domain>**
- **<application_floating_ip> console-openshift-console.apps.<cluster_name>.<base_domain>**
- **application_floating_ip integrated-oauth-server-openshift-authentication.apps.<cluster_name>.<base_domain>**

The cluster domain names in the **/etc/hosts** file grant access to the web console and the monitoring interface of your cluster locally. You can also use the **kubectl** or **oc**. You can access the user applications by using the additional entries pointing to the <application_floating_ip>. This action makes the API and applications accessible to only you, which is not suitable for production deployment, but does allow installation for development and testing.

4. Add the FIPs to the **install-config.yaml** file as the values of the following parameters:
   - **platform.openstack.ingressFloatingIP**
   - **platform.openstack.apiFloatingIP**

If you use these values, you must also enter an external network as the value of the **platform.openstack.externalNetwork** parameter in the **install-config.yaml** file.

TIP

You can make OpenShift Container Platform resources available outside of the cluster by assigning a floating IP address and updating your firewall configuration.

19.3.13.2. Completing installation without floating IP addresses

You can install OpenShift Container Platform on Red Hat OpenStack Platform (RHOSP) without providing floating IP addresses.

In the **install-config.yaml** file, do not define the following parameters:

- **platform.openstack.ingressFloatingIP**
- **platform.openstack.apiFloatingIP**

If you cannot provide an external network, you can also leave **platform.openstack.externalNetwork** blank. If you do not provide a value for **platform.openstack.externalNetwork**, a router is not created for

you, and, without additional action, the installer will fail to retrieve an image from Glance. You must configure external connectivity on your own.

If you run the installer from a system that cannot reach the cluster API due to a lack of floating IP addresses or name resolution, installation fails. To prevent installation failure in these cases, you can use a proxy network or run the installer from a system that is on the same network as your machines.

NOTE

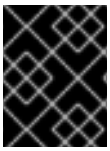
You can enable name resolution by creating DNS records for the API and Ingress ports. For example:

```
api.<cluster_name>.<base_domain>.  IN  A  <api_port_IP>
*.apps.<cluster_name>.<base_domain>. IN  A <ingress_port_IP>
```

If you do not control the DNS server, you can add the record to your **/etc/hosts** file. This action makes the API accessible to only you, which is not suitable for production deployment but does allow installation for development and testing.

19.3.14. Deploying the cluster

You can install OpenShift Container Platform on a compatible cloud platform.



IMPORTANT

You can run the **create cluster** command of the installation program only once, during initial installation.

Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.

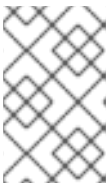
Procedure

- Change to the directory that contains the installation program and initialize the cluster deployment:

```
$ ./openshift-install create cluster --dir <installation_directory> \ 1
    --log-level=info 2
```

1 For **<installation_directory>**, specify the location of your customized **./install-config.yaml** file.

2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.



NOTE

If the cloud provider account that you configured on your host does not have sufficient permissions to deploy the cluster, the installation process stops, and the missing permissions are displayed.

Verification

When the cluster deployment completes successfully:

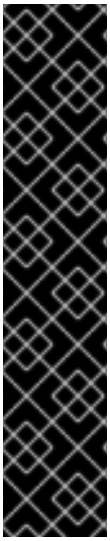
- The terminal displays directions for accessing your cluster, including a link to the web console and credentials for the **kubeadmin** user.
- Credential information also outputs to **<installation_directory>/.openshift_install.log**.

IMPORTANT

Do not delete the installation program or the files that the installation program creates. Both are required to delete the cluster.

Example output

```
...
INFO Install complete!
INFO To access the cluster as the system:admin user when using 'oc', run 'export
KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
INFO Access the OpenShift web-console here: https://console-openshift-
console.apps.mycluster.example.com
INFO Login to the console with user: "kubeadmin", and password: "password"
INFO Time elapsed: 36m22s
```



IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

19.3.15. Verifying cluster status

You can verify your OpenShift Container Platform cluster's status during or after installation.

Procedure

1. In the cluster environment, export the administrator's kubeconfig file:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

1. For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server.

2. View the control plane and compute machines created after a deployment:

```
$ oc get nodes
```

3. View your cluster's version:

```
$ oc get clusterversion
```

4. View your Operators' status:

```
$ oc get clusteroperator
```

5. View all running pods in the cluster:

```
$ oc get pods -A
```

19.3.16. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

Example output

```
system:admin
```

Additional resources

- See Accessing the web console for more details about accessing and understanding the OpenShift Container Platform web console.

19.3.17. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.11, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to OpenShift Cluster Manager Hybrid Cloud Console.

After you confirm that your OpenShift Cluster Manager Hybrid Cloud Console inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, use subscription watch to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

Additional resources

- See About remote health monitoring for more information about the Telemetry service

19.3.18. Next steps

- Customize your cluster.
- If necessary, you can opt out of remote health reporting .
- If you need to enable external access to node ports, configure ingress cluster traffic by using a node port.
- If you did not configure RHOSP to accept application traffic over floating IP addresses, configure RHOSP access with floating IP addresses .

19.4. INSTALLING A CLUSTER ON OPENSTACK WITH KURYR

In OpenShift Container Platform version 4.11, you can install a customized cluster on Red Hat OpenStack Platform (RHOSP) that uses Kuryr SDN. To customize the installation, modify parameters in the **install-config.yaml** before you install the cluster.

19.4.1. Prerequisites

- You reviewed details about the OpenShift Container Platform installation and update processes.
- You read the documentation on selecting a cluster installation method and preparing it for users.
- You verified that OpenShift Container Platform 4.11 is compatible with your RHOSP version by using the Supported platforms for OpenShift clusters section. You can also compare platform support across different versions by viewing the OpenShift Container Platform on RHOSP support matrix.
- You have a storage service installed in RHOSP, such as block storage (Cinder) or object storage (Swift). Object storage is the recommended storage technology for OpenShift Container Platform registry cluster deployment. For more information, see Optimizing storage.

- You understand performance and scalability practices for cluster scaling, control plane sizing, and etcd. For more information, see Recommended host practices.

19.4.2. About Kuryr SDN

Kuryr is a container network interface (CNI) plugin solution that uses the Neutron and Octavia Red Hat OpenStack Platform (RHOSP) services to provide networking for pods and Services.

Kuryr and OpenShift Container Platform integration is primarily designed for OpenShift Container Platform clusters running on RHOSP VMs. Kuryr improves the network performance by plugging OpenShift Container Platform pods into RHOSP SDN. In addition, it provides interconnectivity between pods and RHOSP virtual instances.

Kuryr components are installed as pods in OpenShift Container Platform using the **openshift-kuryr** namespace:

- **kuryr-controller** - a single service instance installed on a **master** node. This is modeled in OpenShift Container Platform as a **Deployment** object.
- **kuryr-cni** - a container installing and configuring Kuryr as a CNI driver on each OpenShift Container Platform node. This is modeled in OpenShift Container Platform as a **DaemonSet** object.

The Kuryr controller watches the OpenShift Container Platform API server for pod, service, and namespace create, update, and delete events. It maps the OpenShift Container Platform API calls to corresponding objects in Neutron and Octavia. This means that every network solution that implements the Neutron trunk port functionality can be used to back OpenShift Container Platform via Kuryr. This includes open source solutions such as Open vSwitch (OVS) and Open Virtual Network (OVN) as well as Neutron-compatible commercial SDNs.

Kuryr is recommended for OpenShift Container Platform deployments on encapsulated RHOSP tenant networks to avoid double encapsulation, such as running an encapsulated OpenShift Container Platform SDN over an RHOSP network.

If you use provider networks or tenant VLANs, you do not need to use Kuryr to avoid double encapsulation. The performance benefit is negligible. Depending on your configuration, though, using Kuryr to avoid having two overlays might still be beneficial.

Kuryr is not recommended in deployments where all of the following criteria are true:

- The RHOSP version is less than 16.
- The deployment uses UDP services, or a large number of TCP services on few hypervisors.

or

- The **ovn-octavia** Octavia driver is disabled.
- The deployment uses a large number of TCP services on few hypervisors.

19.4.3. Resource guidelines for installing OpenShift Container Platform on RHOSP with Kuryr

When using Kuryr SDN, the pods, services, namespaces, and network policies are using resources from the RHOSP quota; this increases the minimum requirements. Kuryr also has some additional requirements on top of what a default install requires.

Use the following quota to satisfy a default cluster's minimum requirements:

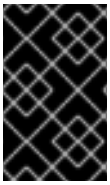
Table 19.7. Recommended resources for a default OpenShift Container Platform cluster on RHOSP with Kuryr

Resource	Value
Floating IP addresses	3 - plus the expected number of Services of LoadBalancer type
Ports	1500 - 1 needed per Pod
Routers	1
Subnets	250 - 1 needed per Namespace/Project
Networks	250 - 1 needed per Namespace/Project
RAM	112 GB
vCPUs	28
Volume storage	275 GB
Instances	7
Security groups	250 - 1 needed per Service and per NetworkPolicy
Security group rules	1000
Server groups	2 - plus 1 for each additional availability zone in each machine pool
Load balancers	100 - 1 needed per Service
Load balancer listeners	500 - 1 needed per Service-exposed port
Load balancer pools	500 - 1 needed per Service-exposed port

A cluster might function with fewer than recommended resources, but its performance is not guaranteed.

IMPORTANT

If RHOSP object storage (Swift) is available and operated by a user account with the **swiftoperator** role, it is used as the default backend for the OpenShift Container Platform image registry. In this case, the volume storage requirement is 175 GB. Swift space requirements vary depending on the size of the image registry.



IMPORTANT

If you are using Red Hat OpenStack Platform (RHOSP) version 16 with the Amphora driver rather than the OVN Octavia driver, security groups are associated with service accounts instead of user projects.

Take the following notes into consideration when setting resources:

- The number of ports that are required is larger than the number of pods. Kuryr uses ports pools to have pre-created ports ready to be used by pods and speed up the pods' booting time.
- Each network policy is mapped into an RHOSP security group, and depending on the **NetworkPolicy** spec, one or more rules are added to the security group.
- Each service is mapped to an RHOSP load balancer. Consider this requirement when estimating the number of security groups required for the quota.
  If you are using RHOSP version 15 or earlier, or the **ovn-octavia driver**, each load balancer has a security group with the user project.
- The quota does not account for load balancer resources (such as VM resources), but you must consider these resources when you decide the RHOSP deployment's size. The default installation will have more than 50 load balancers; the clusters must be able to accommodate them.
  If you are using RHOSP version 16 with the OVN Octavia driver enabled, only one load balancer VM is generated; services are load balanced through OVN flows.

An OpenShift Container Platform deployment comprises control plane machines, compute machines, and a bootstrap machine.

To enable Kuryr SDN, your environment must meet the following requirements:

- Run RHOSP 13+.
- Have Overcloud with Octavia.
- Use Neutron Trunk ports extension.
- Use **openvswitch** firewall driver if ML2/OVS Neutron driver is used instead of **ovs-hybrid**.

19.4.3.1. Increasing quota

When using Kuryr SDN, you must increase quotas to satisfy the Red Hat OpenStack Platform (RHOSP) resources used by pods, services, namespaces, and network policies.

Procedure

- Increase the quotas for a project by running the following command:

```
$ sudo openstack quota set --secgroups 250 --secgroup-rules 1000 --ports 1500 --subnets
250 --networks 250 <project>
```

19.4.3.2. Configuring Neutron

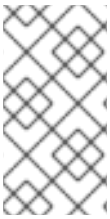
Kuryr CNI leverages the Neutron Trunks extension to plug containers into the Red Hat OpenStack Platform (RHOSP) SDN, so you must use the **trunks** extension for Kuryr to properly work.

In addition, if you leverage the default ML2/OVS Neutron driver, the firewall must be set to **openvswitch** instead of **ovs_hybrid** so that security groups are enforced on trunk subports and Kuryr can properly handle network policies.

19.4.3.3. Configuring Octavia

Kuryr SDN uses Red Hat OpenStack Platform (RHOSP)'s Octavia LBaaS to implement OpenShift Container Platform services. Thus, you must install and configure Octavia components in RHOSP to use Kuryr SDN.

To enable Octavia, you must include the Octavia service during the installation of the RHOSP Overcloud, or upgrade the Octavia service if the Overcloud already exists. The following steps for enabling Octavia apply to both a clean install of the Overcloud or an Overcloud update.



NOTE

The following steps only capture the key pieces required during the deployment of RHOSP when dealing with Octavia. It is also important to note that registry methods vary.

This example uses the local registry method.

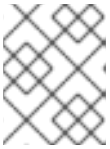
Procedure

1. If you are using the local registry, create a template to upload the images to the registry. For example:

```
(undercloud) $ openstack overcloud container image prepare \
-e /usr/share/openstack-tripleo-heat-templates/environments/services-docker/octavia.yaml \
--namespace=registry.access.redhat.com/rhosp13 \
--push-destination=<local-ip-from-undercloud.conf>:8787 \
--prefix=openstack- \
--tag-from-label {version}-{product-version} \
--output-env-file=/home/stack/templates/overcloud_images.yaml \
--output-images-file /home/stack/local_registry_images.yaml
```

2. Verify that the **local_registry_images.yaml** file contains the Octavia images. For example:

```
...
- imagename: registry.access.redhat.com/rhosp13/openstack-octavia-api:13.0-43
  push_destination: <local-ip-from-undercloud.conf>:8787
- imagename: registry.access.redhat.com/rhosp13/openstack-octavia-health-manager:13.0-
45
  push_destination: <local-ip-from-undercloud.conf>:8787
- imagename: registry.access.redhat.com/rhosp13/openstack-octavia-housekeeping:13.0-45
  push_destination: <local-ip-from-undercloud.conf>:8787
- imagename: registry.access.redhat.com/rhosp13/openstack-octavia-worker:13.0-44
  push_destination: <local-ip-from-undercloud.conf>:8787
```



NOTE

The Octavia container versions vary depending upon the specific RHOSP release installed.

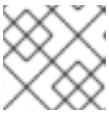
3. Pull the container images from **registry.redhat.io** to the Undercloud node:

```
(undercloud) $ sudo openstack overcloud container image upload \
  --config-file  /home/stack/local_registry_images.yaml \
  --verbose
```

This may take some time depending on the speed of your network and Undercloud disk.

4. Since an Octavia load balancer is used to access the OpenShift Container Platform API, you must increase their listeners' default timeouts for the connections. The default timeout is 50 seconds. Increase the timeout to 20 minutes by passing the following file to the Overcloud deploy command:

```
(undercloud) $ cat octavia_timeouts.yaml
parameter_defaults:
  OctaviaTimeoutClientData: 1200000
  OctaviaTimeoutMemberData: 1200000
```



NOTE

This is not needed for RHOSP 13.0.13+.

5. Install or update your Overcloud environment with Octavia:

```
$ openstack overcloud deploy --templates \
  -e /usr/share/openstack-tripleo-heat-templates/environments/services-docker/octavia.yaml \
  -e octavia_timeouts.yaml
```

NOTE

This command only includes the files associated with Octavia; it varies based on your specific installation of RHOSP. See the RHOSP documentation for further information. For more information on customizing your Octavia installation, see installation of Octavia using Director.

NOTE

When leveraging Kuryr SDN, the Overcloud installation requires the Neutron **trunk** extension. This is available by default on director deployments. Use the **openvswitch** firewall instead of the default **ovs-hybrid** when the Neutron backend is ML2/OVS. There is no need for modifications if the backend is ML2/OVN.

6. In RHOSP versions earlier than 13.0.13, add the project ID to the **octavia.conf** configuration file after you create the project.

   - To enforce network policies across services, like when traffic goes through the Octavia load balancer, you must ensure Octavia creates the Amphora VM security groups on the user project.
     This change ensures that required load balancer security groups belong to that project, and that they can be updated to enforce services isolation.

NOTE

This task is unnecessary in RHOSP version 13.0.13 or later.

Octavia implements a new ACL API that restricts access to the load balancers VIP.

a. Get the project ID

```
$ openstack project show <project>
```

Example output

```
+-------------+----------------------------------+
| Field       | Value                            |
+-------------+----------------------------------+
| description |                                  |
| domain_id   | default                          |
| enabled     | True                             |
| id          | PROJECT_ID                       |
| is_domain   | False                            |
| name        | *<project>*                      |
| parent_id   | default                          |
| tags        | []                               |
+-------------+----------------------------------+
```

b. Add the project ID to **octavia.conf** for the controllers.

i. Source the **stackrc** file:

```
$ source stackrc  # Undercloud credentials
```

ii. List the Overcloud controllers:

```
$ openstack server list
```

Example output

```
+--------------------------------------+-------------+--------+----------------------+-------
--------+------------+
|
| ID                                   | Name        | Status | Networks
| Image          | Flavor     |
|
+--------------------------------------+-------------+--------+----------------------+-------
--------+------------+
|
| 6bef8e73-2ba5-4860-a0b1-3937f8ca7e01 | controller-0 | ACTIVE |
ctlplane=192.168.24.8 | overcloud-full | controller |
|
| dda3173a-ab26-47f8-a2dc-8473b4a67ab9 | compute-0    | ACTIVE |
ctlplane=192.168.24.6 | overcloud-full | compute    |
```

```
|
+--------------------------------------+-------------+--------+----------------------+-------
---------+------------+
```

iii. SSH into the controller(s).

```
$ ssh heat-admin@192.168.24.8
```

iv. Edit the **octavia.conf** file to add the project into the list of projects where Amphora security groups are on the user's account.

```
# List of project IDs that are allowed to have Load balancer security groups
# belonging to them.
amp_secgroup_allowed_projects = PROJECT_ID
```

c. Restart the Octavia worker so the new configuration loads.

```
controller-0$ sudo docker restart octavia_worker
```

NOTE

Depending on your RHOSP environment, Octavia might not support UDP listeners. If you use Kuryr SDN on RHOSP version 13.0.13 or earlier, UDP services are not supported. RHOSP version 16 or later support UDP.

19.4.3.3.1. The Octavia OVN Driver

Octavia supports multiple provider drivers through the Octavia API.

To see all available Octavia provider drivers, on a command line, enter:

```
$ openstack loadbalancer provider list
```

Example output

```
+---------+-------------------------------------------------+
| name    | description                                     |
+---------+-------------------------------------------------+
| amphora | The Octavia Amphora driver.                     |
| octavia | Deprecated alias of the Octavia Amphora driver. |
| ovn     | Octavia OVN driver.                             |
+---------+-------------------------------------------------+
```

Beginning with RHOSP version 16, the Octavia OVN provider driver (**ovn**) is supported on OpenShift Container Platform on RHOSP deployments.

ovn is an integration driver for the load balancing that Octavia and OVN provide. It supports basic load balancing capabilities, and is based on OpenFlow rules. The driver is automatically enabled in Octavia by Director on deployments that use OVN Neutron ML2.

The Amphora provider driver is the default driver. If **ovn** is enabled, however, Kuryr uses it.

If Kuryr uses **ovn** instead of Amphora, it offers the following benefits:

- Decreased resource requirements. Kuryr does not require a load balancer VM for each service.
- Reduced network latency.
- Increased service creation speed by using OpenFlow rules instead of a VM for each service.
- Distributed load balancing actions across all nodes instead of centralized on Amphora VMs.

You can configure your cluster to use the Octavia OVN driver after your RHOSP cloud is upgraded from version 13 to version 16.

19.4.3.4. Known limitations of installing with Kuryr

Using OpenShift Container Platform with Kuryr SDN has several known limitations.

RHOSP general limitations
Using OpenShift Container Platform with Kuryr SDN has several limitations that apply to all versions and environments:

- **Service** objects with the **NodePort** type are not supported.
- Clusters that use the OVN Octavia provider driver support **Service** objects for which the **.spec.selector** property is unspecified only if the **.subsets.addresses** property of the **Endpoints** object includes the subnet of the nodes or pods.
- If the subnet on which machines are created is not connected to a router, or if the subnet is connected, but the router has no external gateway set, Kuryr cannot create floating IPs for **Service** objects with type **LoadBalancer**.
- Configuring the **sessionAffinity=ClientIP** property on **Service** objects does not have an effect. Kuryr does not support this setting.

RHOSP version limitations
Using OpenShift Container Platform with Kuryr SDN has several limitations that depend on the RHOSP version.

- RHOSP versions before 16 use the default Octavia load balancer driver (Amphora). This driver requires that one Amphora load balancer VM is deployed per OpenShift Container Platform service. Creating too many services can cause you to run out of resources.
  Deployments of later versions of RHOSP that have the OVN Octavia driver disabled also use the Amphora driver. They are subject to the same resource concerns as earlier versions of RHOSP.
- Octavia RHOSP versions before 13.0.13 do not support UDP listeners. Therefore, OpenShift Container Platform UDP services are not supported.
- Octavia RHOSP versions before 13.0.13 cannot listen to multiple protocols on the same port. Services that expose the same port to different protocols, like TCP and UDP, are not supported.
- Kuryr SDN does not support automatic unidling by a service.

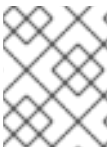
RHOSP environment limitations
There are limitations when using Kuryr SDN that depend on your deployment environment.

Because of Octavia's lack of support for the UDP protocol and multiple listeners, if the RHOSP version is earlier than 13.0.13, Kuryr forces pods to use TCP for DNS resolution.

In Go versions 1.12 and earlier, applications that are compiled with CGO support disabled use UDP only. In this case, the native Go resolver does not recognize the **use-vc** option in **resolv.conf**, which controls whether TCP is forced for DNS resolution. As a result, UDP is still used for DNS resolution, which fails.

To ensure that TCP forcing is allowed, compile applications either with the environment variable **CGO_ENABLED** set to **1**, i.e. **CGO_ENABLED=1**, or ensure that the variable is absent.

In Go versions 1.13 and later, TCP is used automatically if DNS resolution using UDP fails.



NOTE

musl-based containers, including Alpine-based containers, do not support the **use-vc** option.

RHOSP upgrade limitations
As a result of the RHOSP upgrade process, the Octavia API might be changed, and upgrades to the Amphora images that are used for load balancers might be required.

You can address API changes on an individual basis.

If the Amphora image is upgraded, the RHOSP operator can handle existing load balancer VMs in two ways:

- Upgrade each VM by triggering a load balancer failover.
- Leave responsibility for upgrading the VMs to users.

If the operator takes the first option, there might be short downtimes during failovers.

If the operator takes the second option, the existing load balancers will not support upgraded Octavia API features, like UDP listeners. In this case, users must recreate their Services to use these features.

IMPORTANT

If OpenShift Container Platform detects a new Octavia version that supports UDP load balancing, it recreates the DNS service automatically. The service recreation ensures that the service default supports UDP load balancing.

The recreation causes the DNS service approximately one minute of downtime.

19.4.3.5. Control plane machines

By default, the OpenShift Container Platform installation process creates three control plane machines.

Each machine requires:

- An instance from the RHOSP quota
- A port from the RHOSP quota
- A flavor with at least 16 GB memory and 4 vCPUs
- At least 100 GB storage space from the RHOSP quota

19.4.3.6. Compute machines

By default, the OpenShift Container Platform installation process creates three compute machines.

Each machine requires:

- An instance from the RHOSP quota
- A port from the RHOSP quota
- A flavor with at least 8 GB memory and 2 vCPUs
- At least 100 GB storage space from the RHOSP quota

TIP

Compute machines host the applications that you run on OpenShift Container Platform; aim to run as many as you can.

19.4.3.7. Bootstrap machine

During installation, a bootstrap machine is temporarily provisioned to stand up the control plane. After the production control plane is ready, the bootstrap machine is deprovisioned.

The bootstrap machine requires:

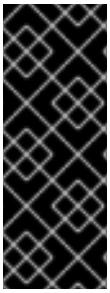
- An instance from the RHOSP quota
- A port from the RHOSP quota
- A flavor with at least 16 GB memory and 4 vCPUs
- At least 100 GB storage space from the RHOSP quota

19.4.4. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.11, you require access to the internet to install your cluster.

You must have internet access to:

- Access OpenShift Cluster Manager Hybrid Cloud Console to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access Quay.io to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.

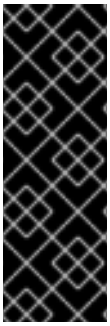


IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

19.4.5. Enabling Swift on RHOSP

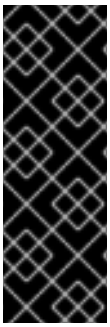
Swift is operated by a user account with the **swiftoperator** role. Add the role to an account before you run the installation program.



IMPORTANT

If the Red Hat OpenStack Platform (RHOSP) object storage service , commonly known as Swift, is available, OpenShift Container Platform uses it as the image registry storage. If it is unavailable, the installation program relies on the RHOSP block storage service, commonly known as Cinder.

If Swift is present and you want to use it, you must enable access to it. If it is not present, or if you do not want to use it, skip this section.



IMPORTANT

RHOSP 17 sets the **rgw_max_attr_size** parameter of Ceph RGW to 256 characters. This setting causes issues with uploading container images to the OpenShift Container Platform registry. You must set the value of **rgw_max_attr_size** to at least 1024 characters.

Before installation, check if your RHOSP deployment is affected by this problem. If it is, reconfigure Ceph RGW.

Prerequisites

- You have a RHOSP administrator account on the target environment.
- The Swift service is installed.
- On Ceph RGW, the **account in url** option is enabled.

Procedure

To enable Swift on RHOSP:

1. As an administrator in the RHOSP CLI, add the **swiftoperator** role to the account that will access Swift:

```
$ openstack role add --user <user> --project <project> swiftoperator
```

Your RHOSP deployment can now use Swift for the image registry.

19.4.6. Verifying external network access

The OpenShift Container Platform installation process requires external network access. You must provide an external network value to it, or deployment fails. Before you begin the process, verify that a network with the external router type exists in Red Hat OpenStack Platform (RHOSP).

Prerequisites

- Configure OpenStack's networking service to have DHCP agents forward instances' DNS queries

Procedure

1. Using the RHOSP CLI, verify the name and ID of the 'External' network:

```
$ openstack network list --long -c ID -c Name -c "Router Type"
```

Example output

```
+--------------------------------------+----------------+-------------+
| ID                                   | Name           | Router Type |
+--------------------------------------+----------------+-------------+
| 148a8023-62a7-4672-b018-003462f8d7dc | public_network | External    |
+--------------------------------------+----------------+-------------+
```

A network with an external router type appears in the network list. If at least one does not, see Creating a default floating IP network and Creating a default provider network .

IMPORTANT

If the external network's CIDR range overlaps one of the default network ranges, you must change the matching network ranges in the **install-config.yaml** file before you start the installation process.

The default network ranges are:

Network	Range
machineNetwork	10.0.0.0/16
serviceNetwork	172.30.0.0/16
clusterNetwork	10.128.0.0/14

WARNING

If the installation program finds multiple networks with the same name, it sets one of them at random. To avoid this behavior, create unique names for resources in RHOSP.

NOTE

If the Neutron trunk service plugin is enabled, a trunk port is created by default. For more information, see Neutron trunk port .

19.4.7. Defining parameters for the installation program

The OpenShift Container Platform installation program relies on a file that is called **clouds.yaml**. The file describes Red Hat OpenStack Platform (RHOSP) configuration parameters, including the project name, log in information, and authorization service URLs.

Procedure

1. Create the **clouds.yaml** file:

   - If your RHOSP distribution includes the Horizon web UI, generate a **clouds.yaml** file in it.

     IMPORTANT

     Remember to add a password to the **auth** field. You can also keep secrets in a separate file from **clouds.yaml**. OpenShift Container Platform does not support application credentials.

   - If your RHOSP distribution does not include the Horizon web UI, or you do not want to use Horizon, create the file yourself. For detailed information about **clouds.yaml**, see Config files in the RHOSP documentation.

     ```
     clouds:
       shiftstack:
         auth:
           auth_url: http://10.10.14.42:5000/v3
           project_name: shiftstack
           username: <username>
           password: <password>
           user_domain_name: Default
           project_domain_name: Default
       dev-env:
         region_name: RegionOne
         auth:
           username: <username>
           password: <password>
           project_name: 'devonly'
           auth_url: 'https://10.10.14.22:5001/v2.0'
     ```

2. If your RHOSP installation uses self-signed certificate authority (CA) certificates for endpoint authentication:

   a. Copy the certificate authority file to your machine.

   b. Add the **cacerts** key to the **clouds.yaml** file. The value must be an absolute, non-root-accessible path to the CA certificate:

      ```
      clouds:
        shiftstack:
          ...
          cacert: "/etc/pki/ca-trust/source/anchors/ca.crt.pem"
      ```

TIP

After you run the installer with a custom CA certificate, you can update the certificate by editing the value of the **ca-cert.pem** key in the **cloud-provider-config** keymap. On a command line, run:

```
$ oc edit configmap -n openshift-config cloud-provider-config
```

3. Place the **clouds.yaml** file in one of the following locations:
   a. The value of the **OS_CLIENT_CONFIG_FILE** environment variable
   b. The current directory
   c. A Unix-specific user configuration directory, for example ~/**.config/openstack/clouds.yaml**
   d. A Unix-specific site configuration directory, for example /**etc/openstack/clouds.yaml**
   The installation program searches for **clouds.yaml** in that order.

19.4.8. Setting cloud provider options

Optionally, you can edit the cloud provider configuration for your cluster. The cloud provider configuration controls how OpenShift Container Platform interacts with Red Hat OpenStack Platform (RHOSP).

For a complete list of cloud provider configuration parameters, see the "OpenStack cloud configuration reference guide" page in the "Installing on OpenStack" documentation.

Procedure

1. If you have not already generated manifest files for your cluster, generate them by running the following command:

```
$ openshift-install --dir <destination_directory> create manifests
```

2. In a text editor, open the cloud-provider configuration manifest file. For example:

```
$ vi openshift/manifests/cloud-provider-config.yaml
```

3. Modify the options based on the cloud configuration specification.
   Configuring Octavia for load balancing is a common case for clusters that do not use Kuryr. For example:

```
#...
[LoadBalancer]
use-octavia=true 1
lb-provider = "amphora" 2
floating-network-id="d3deb660-4190-40a3-91f1-37326fe6ec4a" 3
create-monitor = True 4
monitor-delay = 10s 5
monitor-timeout = 10s 6
monitor-max-retries = 1 7
#...
```

1. This property enables Octavia integration.
2. This property sets the Octavia provider that your load balancer uses. It accepts **"ovn"** or **"amphora"** as values. If you choose to use OVN, you must also set **lb-method** to **SOURCE_IP_PORT**.
3. This property is required if you want to use multiple external networks with your cluster. The cloud provider creates floating IP addresses on the network that is specified here.
4. This property controls whether the cloud provider creates health monitors for Octavia load balancers. Set the value to **True** to create health monitors. As of RHOSP 16.1 and 16.2, this feature is only available for the Amphora provider.
5. This property sets the frequency with which endpoints are monitored. The value must be in the **time.ParseDuration()** format. This property is required if the value of the **create-monitor** property is **True**.
6. This property sets the time that monitoring requests are open before timing out. The value must be in the **time.ParseDuration()** format. This property is required if the value of the **create-monitor** property is **True**.
7. This property defines how many successful monitoring requests are required before a load balancer is marked as online. The value must be an integer. This property is required if the value of the **create-monitor** property is **True**.

IMPORTANT

Prior to saving your changes, verify that the file is structured correctly. Clusters might fail if properties are not placed in the appropriate section.

IMPORTANT

You must set the value of the **create-monitor** property to **True** if you use services that have the value of the **.spec.externalTrafficPolicy** property set to **Local**. The OVN Octavia provider in RHOSP 16.1 and 16.2 does not support health monitors. Therefore, services that have **ETP** parameter values set to **Local** might not respond when the **lb-provider** value is set to **"ovn"**.

IMPORTANT

For installations that use Kuryr, Kuryr handles relevant services. There is no need to configure Octavia load balancing in the cloud provider.

4. Save the changes to the file and proceed with installation.

TIP

You can update your cloud provider configuration after you run the installer. On a command line, run:

```
$ oc edit configmap -n openshift-config cloud-provider-config
```

After you save your changes, your cluster will take some time to reconfigure itself. The process is complete if none of your nodes have a **SchedulingDisabled** status.

19.4.8.1. External load balancers that use pre-defined floating IP addresses

Commonly, Red Hat OpenStack Platform (RHOSP) deployments disallow non-administrator users from creating specific floating IP addresses. If such a policy is in place and you use a floating IP address in your service specification, the cloud provider will fail to handle IP address assignment to load balancers.

If you use an external cloud provider, you can avoid this problem by pre-creating a floating IP address and specifying it in your service specification. The in-tree cloud provider does not support this method.

Alternatively, you can modify the RHOSP Networking service (Neutron) to allow non-administrator users to create specific floating IP addresses.

Additional resources

- For more information about cloud provider configuration, see OpenStack cloud provider options.

19.4.9. Obtaining the installation program

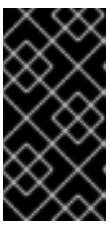
Before you install OpenShift Container Platform, download the installation file on a local computer.

Prerequisites

- You have a computer that runs Linux or macOS, with 500 MB of local disk space.

Procedure

1. Access the Infrastructure Provider page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program that corresponds with your host operating system and architecture, and place the file in the directory where you will store the installation configuration files.



IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.

IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation pull secret from the Red Hat OpenShift Cluster Manager . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

19.4.10. Creating the installation configuration file

You can customize the OpenShift Container Platform cluster you install on Red Hat OpenStack Platform (RHOSP).

Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.
- Obtain service principal permissions at the subscription level.

Procedure

1. Create the **install-config.yaml** file.
   a. Change to the directory that contains the installation program and run the following command:

```
$ ./openshift-install create install-config --dir <installation_directory> 1
```

   1 For **<installation_directory>**, specify the directory name to store the files that the installation program creates.

   When specifying the directory:

   - Verify that the directory has the **execute** permission. This permission is required to run Terraform binaries under the installation directory.
   - Use an empty directory. Some installation assets, such as bootstrap X.509 certificates, have short expiration intervals, therefore you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

   b. At the prompts, provide the configuration details for your cloud:

i. Optional: Select an SSH key to use to access your cluster machines.

NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

ii. Select **openstack** as the platform to target.

iii. Specify the Red Hat OpenStack Platform (RHOSP) external network name to use for installing the cluster.

iv. Specify the floating IP address to use for external access to the OpenShift API.

v. Specify a RHOSP flavor with at least 16 GB RAM to use for control plane nodes and 8 GB RAM for compute nodes.

vi. Select the base domain to deploy the cluster to. All DNS records will be sub-domains of this base and will also include the cluster name.

vii. Enter a name for your cluster. The name must be 14 or fewer characters long.

viii. Paste the pull secret from the Red Hat OpenShift Cluster Manager .

2. Modify the **install-config.yaml** file. You can find more information about the available parameters in the "Installation configuration parameters" section.

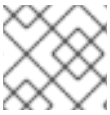
3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.

IMPORTANT

The **install-config.yaml** file is consumed during the installation process. If you want to reuse the file, you must back it up now.

19.4.10.1. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.



NOTE

Kuryr installations default to HTTP proxies.

Prerequisites

- For Kuryr installations on restricted networks that use the **Proxy** object, the proxy must be able to reply to the router that the cluster uses. To add a static route for the proxy configuration, from a command line as the root user, enter:

```
$ ip route add <cluster_network_cidr> via <installer_subnet_gateway>
```

- The restricted subnet must have a gateway that is defined and available to be linked to the **Router** resource that Kuryr creates.
- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.

NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

Procedure

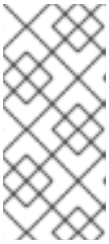
1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
```

1. A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
2. A proxy URL to use for creating HTTPS connections outside the cluster.
3. A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use * to bypass the proxy for all destinations.
4. If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace that contains one or more additional CA certificates that are required for proxying HTTPS connections. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges these contents with the Red Hat Enterprise Linux CoreOS (RHCOS) trust bundle, and this config map is referenced in the **trustedCA** field of the **Proxy** object. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.

NOTE

The installation program does not support the proxy **readinessEndpoints** field.



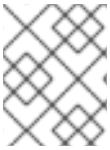
NOTE

If the installer times out, restart and then complete the deployment by using the **wait-for** command of the installer. For example:

```
$ ./openshift-install wait-for install-complete --log-level debug
```

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.



NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

19.4.11. Installation configuration parameters

Before you deploy an OpenShift Container Platform cluster, you provide parameter values to describe your account on the cloud platform that hosts your cluster and optionally customize your cluster's platform. When you create the **install-config.yaml** installation configuration file, you provide values for the required parameters through the command line. If you customize your cluster, you can modify the **install-config.yaml** file to provide more details about the platform.

NOTE

After installation, you cannot modify these parameters in the **install-config.yaml** file.

19.4.11.1. Required configuration parameters

Required installation configuration parameters are described in the following table:

Table 19.8. Required parameters

Parameter	Description	Values
apiVersion	The API version for the **install-config.yaml** content. The current version is **v1**. The installer may also support older API versions.	String

Parameter	Description	Values
baseDomain	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the **baseDomain** and **metadata.name** parameter values that uses the **<metadata.name>.<baseDomain>** format.	A fully-qualified domain or subdomain name, such as **example.com**.
metadata	Kubernetes resource **ObjectMeta**, from which only the **name** parameter is consumed.	Object
metadata.name	The name of the cluster. DNS records for the cluster are all subdomains of **{{.metadata.name}}.{{.baseDomain}}**.	String of lowercase letters, hyphens (**-**), and periods (**.**), such as **dev**. The string must be 14 characters or fewer long.
platform	The configuration for the specific platform upon which to perform the installation: **alibabacloud**, **aws**, **baremetal**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**. For additional information about **platform.<platform>** parameters, consult the table for your specific platform that follows.	Object

Parameter	Description	Values
pullSecret	Get a pull secret from the Red Hat OpenShift Cluster Manager to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	<pre>{ "auths":{ "cloud.openshift.com":{ "auth":"b3Blb=", "email":"you@example.com" }, "quay.io":{ "auth":"b3Blb=", "email":"you@example.com" } } }</pre>

19.4.11.2. Network configuration parameters

You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

Only IPv4 addresses are supported.

NOTE

Globalnet is not supported with Red Hat OpenShift Data Foundation disaster recovery solutions. For regional disaster recovery scenarios, ensure that you use a nonoverlapping range of private IP addresses for the cluster and service networks in each cluster.

Table 19.9. Network parameters

Parameter	Description	Values
networking	The configuration for the cluster network.	Object  **NOTE** You cannot modify parameters specified by the **networking** object after installation.

Parameter	Description	Values
networking.networkType	The cluster network provider Container Network Interface (CNI) cluster network provider to install.	Either **OpenShiftSDN** or **OVNKubernetes**. **OpenShiftSDN** is a CNI provider for all-Linux networks. **OVNKubernetes** is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is **OpenShiftSDN**.
networking.clusterNetwork	The IP address blocks for pods. The default value is **10.128.0.0/14** with a host prefix of **/23**. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: networking: clusterNetwork: - cidr: 10.128.0.0/14 hostPrefix: 23
networking.clusterNetwork.cidr	Required if you use **networking.clusterNetwork**. An IP address block. An IPv4 network.	An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between **0** and **32**.
networking.clusterNetwork.hostPrefix	The subnet prefix length to assign to each individual node. For example, if **hostPrefix** is set to **23** then each node is assigned a **/23** subnet out of the given **cidr**. A **hostPrefix** value of **23** provides 510 (2^(32 - 23) - 2) pod IP addresses.	A subnet prefix. The default value is **23**.
networking.serviceNetwork	The IP address block for services. The default value is **172.30.0.0/16**. The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.	An array with an IP address block in CIDR format. For example: networking: serviceNetwork: - 172.30.0.0/16
networking.machineNetwork	The IP address blocks for machines. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: networking: machineNetwork: - cidr: 10.0.0.0/16

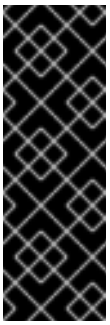
Parameter	Description	Values
networking.machineNetwork.cidr	Required if you use **networking.machineNetwork**. An IP address block. The default value is **10.0.0.0/16** for all platforms other than libvirt. For libvirt, the default value is **192.168.126.0/24**.	An IP network block in CIDR notation. For example, **10.0.0.0/16**.  **NOTE** Set the **networking.machineNetwork** to match the CIDR that the preferred NIC resides in.

19.4.11.3. Optional configuration parameters

Optional installation configuration parameters are described in the following table:

Table 19.10. Optional parameters

Parameter	Description	Values
additionalTrustBundle	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String
capabilities	Controls the installation of optional core cluster components. You can reduce the footprint of your OpenShift Container Platform cluster by disabling optional components.	String array
capabilities.baselineCapabilitySet	Selects an initial set of optional capabilities to enable. Valid values are **None**, **v4.11** and **vCurrent**. **v4.11** enables the **baremetal** Operator, the **marketplace** Operator, and the **openshift-samples** content. **vCurrent** installs the recommended set of capabilities for the current version of OpenShift Container Platform. The default value is **vCurrent**.	String

Parameter	Description	Values
capabilities.additionalEnabledCapabilities	Extends the set of optional capabilities beyond what you specify in **baselineCapabilitySet**. Valid values are **baremetal**, **marketplace** and **openshift-samples**. You may specify multiple capabilities in this parameter.	String array
cgroupsV2	Enables Linux control groups version 2 (cgroups v2) on specific nodes in your cluster. The OpenShift Container Platform process for enabling cgroups v2 disables all cgroup version 1 controllers and hierarchies. The OpenShift Container Platform cgroups version 2 feature is in Developer Preview and is not supported by Red Hat at this time.	**true**
compute	The configuration for the machines that comprise the compute nodes.	Array of **MachinePool** objects.
compute.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** (the default).	String
compute.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  IMPORTANT If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
compute.name	Required if you use **compute**. The name of the machine pool.	**worker**

Parameter	Description	Values
compute.platform	Required if you use **compute**. Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the **controlPlane.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
compute.replicas	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to **2**. The default value is **3**.
controlPlane	The configuration for the machines that comprise the control plane.	Array of **MachinePool** objects.
controlPlane.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** (the default).	String
controlPlane.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  IMPORTANT If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
controlPlane.name	Required if you use **controlPlane**. The name of the machine pool.	**master**

Parameter	Description	Values
controlPlane.platform	Required if you use **controlPlane**. Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the **compute.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
controlPlane.replicas	The number of control plane machines to provision.	The only supported value is **3**, which is the default value.
credentialsMode	The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported.  **NOTE** Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the *Cloud Credential Operator* entry in the *Cluster Operators reference* content.  **NOTE** If your AWS account has service control policies (SCP) enabled, you must configure the **credentialsMode** parameter to **Mint**, **Passthrough** or **Manual**.	**Mint**, **Passthrough**, **Manual** or an empty string (**""**).

Parameter	Description	Values
fips	Enable or disable FIPS mode. The default is **false** (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.  **IMPORTANT** To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.  **NOTE** If you are using Azure File storage, you cannot enable FIPS mode.	**false** or **true**
imageContentSources	Sources and repositories for the release-image content.	Array of objects. Includes a **source** and, optionally, **mirrors**, as described in the following rows of this table.
imageContentSources.source	Required if you use **imageContentSources**. Specify the repository that users refer to, for example, in image pull specifications.	String

Parameter	Description	Values
imageContentSources.mirrors	Specify one or more repositories that may also contain the same images.	Array of strings
publish	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	**Internal** or **External**. The default value is **External**. Setting this field to **Internal** is not supported on non-cloud platforms and IBM Cloud VPC.  **IMPORTANT** If the value of the field is set to **Internal**, the cluster will become non-functional. For more information, refer to BZ#1953035.
sshKey	The SSH key to authenticate access to your cluster machines.  **NOTE** For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.	For example, **sshKey: ssh-ed25519 AAAA..**.

19.4.11.4. Additional Red Hat OpenStack Platform (RHOSP) configuration parameters

Additional RHOSP configuration parameters are described in the following table:

Table 19.11. Additional RHOSP parameters

Parameter	Description	Values
compute.platform.openstack.rootVolume.size	For compute machines, the size in gigabytes of the root volume. If you do not set this value, machines use ephemeral storage.	Integer, for example **30**.

Parameter	Description	Values
compute.platform.openstack.rootVolume.type	For compute machines, the root volume's type.	String, for example **performance**.
controlPlane.platform.openstack.rootVolume.size	For control plane machines, the size in gigabytes of the root volume. If you do not set this value, machines use ephemeral storage.	Integer, for example **30**.
controlPlane.platform.openstack.rootVolume.type	For control plane machines, the root volume's type.	String, for example **performance**.
platform.openstack.cloud	The name of the RHOSP cloud to use from the list of clouds in the **clouds.yaml** file.	String, for example **MyCloud**.
platform.openstack.externalNetwork	The RHOSP external network name to be used for installation.	String, for example **external**.
platform.openstack.computeFlavor	The RHOSP flavor to use for control plane and compute machines. This property is deprecated. To use a flavor as the default for all machine pools, add it as the value of the **type** key in the **platform.openstack.defaultMachinePlatform** property. You can also set a flavor value for each machine pool individually.	String, for example **m1.xlarge**.

19.4.11.5. Optional RHOSP configuration parameters

Optional RHOSP configuration parameters are described in the following table:

Table 19.12. Optional RHOSP parameters

Parameter	Description	Values
compute.platform.openstack.additionalNetworkIDs	Additional networks that are associated with compute machines. Allowed address pairs are not created for additional networks.	A list of one or more UUIDs as strings. For example, **fa806b2f-ac49-4bce-b9db-124bc64209bf**.
compute.platform.openstack.additionalSecurityGroupIDs	Additional security groups that are associated with compute machines.	A list of one or more UUIDs as strings. For example, **7ee219f3-d2e9-48a1-96c2-e7429f1b0da7**.
compute.platform.openstack.zones	RHOSP Compute (Nova) availability zones (AZs) to install machines on. If this parameter is not set, the installer relies on the default settings for Nova that the RHOSP administrator configured. On clusters that use Kuryr, RHOSP Octavia does not support availability zones. Load balancers and, if you are using the Amphora provider driver, OpenShift Container Platform services that rely on Amphora VMs, are not created according to the value of this property.	A list of strings. For example, **["zone-1", "zone-2"]**.
compute.platform.openstack.rootVolume.zones	For compute machines, the availability zone to install root volumes on. If you do not set a value for this parameter, the installer selects the default availability zone.	A list of strings, for example **["zone-1", "zone-2"]**.

Parameter	Description	Values
compute.platform.openstack.serverGroupPolicy	Server group policy to apply to the group that will contain the compute machines in the pool. You cannot change server group policies or affiliations after creation. Supported options include **anti-affinity**, **soft-affinity**, and **soft-anti-affinity**. The default value is **soft-anti-affinity**. An **affinity** policy prevents migrations and therefore affects RHOSP upgrades. The **affinity** policy is not supported. If you use a strict **anti-affinity** policy, an additional RHOSP host is required during instance migration.	A server group policy to apply to the machine pool. For example, **soft-affinity**.
controlPlane.platform.openstack.additionalNetworkIDs	Additional networks that are associated with control plane machines. Allowed address pairs are not created for additional networks.	A list of one or more UUIDs as strings. For example, **fa806b2f-ac49-4bce-b9db-124bc64209bf**.
controlPlane.platform.openstack.additionalSecurityGroupIDs	Additional security groups that are associated with control plane machines.	A list of one or more UUIDs as strings. For example, **7ee219f3-d2e9-48a1-96c2-e7429f1b0da7**.

Parameter	Description	Values
controlPlane.platform.openstack.zones	RHOSP Compute (Nova) availability zones (AZs) to install machines on. If this parameter is not set, the installer relies on the default settings for Nova that the RHOSP administrator configured. On clusters that use Kuryr, RHOSP Octavia does not support availability zones. Load balancers and, if you are using the Amphora provider driver, OpenShift Container Platform services that rely on Amphora VMs, are not created according to the value of this property.	A list of strings. For example, **["zone-1", "zone-2"]**.
controlPlane.platform.openstack.rootVolume.zones	For control plane machines, the availability zone to install root volumes on. If you do not set this value, the installer selects the default availability zone.	A list of strings, for example **["zone-1", "zone-2"]**.
controlPlane.platform.openstack.serverGroupPolicy	Server group policy to apply to the group that will contain the control plane machines in the pool. You cannot change server group policies or affiliations after creation. Supported options include **anti-affinity**, **soft-affinity**, and **soft-anti-affinity**. The default value is **soft-anti-affinity**. An **affinity** policy prevents migrations, and therefore affects RHOSP upgrades. The **affinity** policy is not supported. If you use a strict **anti-affinity** policy, an additional RHOSP host is required during instance migration.	A server group policy to apply to the machine pool. For example, **soft-affinity**.

Parameter	Description	Values
platform.openstack.clusterOSImage	The location from which the installer downloads the RHCOS image. You must set this parameter to perform an installation in a restricted network.	An HTTP or HTTPS URL, optionally with an SHA-256 checksum. For example, **http://mirror.example.com/images/rhcos-43.81.201912131630.0-openstack.x86_64.qcow2.gz?sha256=ffebbd68e8a1f2a245ca19522c16c86f67f9ac8e4e0c1f0a812b068b16f7265d**. The value can also be the name of an existing Glance image, for example **my-rhcos**.
platform.openstack.clusterOSImageProperties	Properties to add to the installer-uploaded ClusterOSImage in Glance. This property is ignored if **platform.openstack.clusterOSImage** is set to an existing Glance image. You can use this property to exceed the default persistent volume (PV) limit for RHOSP of 26 PVs per node. To exceed the limit, set the **hw_scsi_model** property value to **virtio-scsi** and the **hw_disk_bus** value to **scsi**. You can also use this property to enable the QEMU guest agent by including the **hw_qemu_guest_agent** property with a value of **yes**.	A list of key-value string pairs. For example, **["hw_scsi_model": "virtio-scsi", "hw_disk_bus": "scsi"]**.
platform.openstack.defaultMachinePlatform	The default machine pool platform configuration.	<pre>{ "type": "ml.large", "rootVolume": { "size": 30, "type": "performance" } }</pre>
platform.openstack.ingressFloatingIP	An existing floating IP address to associate with the Ingress port. To use this property, you must also define the **platform.openstack.externalNetwork** property.	An IP address, for example **128.0.0.1**.

Parameter	Description	Values
platform.openstack.apiFloatingIP	An existing floating IP address to associate with the API load balancer. To use this property, you must also define the **platform.openstack.externalNetwork** property.	An IP address, for example **128.0.0.1**.
platform.openstack.externalDNS	IP addresses for external DNS servers that cluster instances use for DNS resolution.	A list of IP addresses as strings. For example, **["8.8.8.8", "192.168.1.12"]**.
platform.openstack.machinesSubnet	The UUID of a RHOSP subnet that the cluster's nodes use. Nodes and virtual IP (VIP) ports are created on this subnet. The first item in **networking.machineNetwork** must match the value of **machinesSubnet**. If you deploy to a custom subnet, you cannot specify an external DNS server to the OpenShift Container Platform installer. Instead, add DNS to the subnet in RHOSP.	A UUID as a string. For example, **fa806b2f-ac49-4bce-b9db-124bc64209bf**.

19.4.11.6. Custom subnets in RHOSP deployments

Optionally, you can deploy a cluster on a Red Hat OpenStack Platform (RHOSP) subnet of your choice. The subnet's GUID is passed as the value of **platform.openstack.machinesSubnet** in the **install-config.yaml** file.

This subnet is used as the cluster's primary subnet. By default, nodes and ports are created on it. You can create nodes and ports on a different RHOSP subnet by setting the value of the **platform.openstack.machinesSubnet** property to the subnet's UUID.

Before you run the OpenShift Container Platform installer with a custom subnet, verify that your configuration meets the following requirements:

- The subnet that is used by **platform.openstack.machinesSubnet** has DHCP enabled.
- The CIDR of **platform.openstack.machinesSubnet** matches the CIDR of **networking.machineNetwork**.
- The installation program user has permission to create ports on this network, including ports with fixed IP addresses.

Clusters that use custom subnets have the following limitations:

- If you plan to install a cluster that uses floating IP addresses, the **platform.openstack.machinesSubnet** subnet must be attached to a router that is connected to the **externalNetwork** network.
- If the **platform.openstack.machinesSubnet** value is set in the **install-config.yaml** file, the installation program does not create a private network or subnet for your RHOSP machines.
- You cannot use the **platform.openstack.externalDNS** property at the same time as a custom subnet. To add DNS to a cluster that uses a custom subnet, configure DNS on the RHOSP network.

NOTE

By default, the API VIP takes x.x.x.5 and the Ingress VIP takes x.x.x.7 from your network's CIDR block. To override these default values, set values for **platform.openstack.apiVIP** and **platform.openstack.ingressVIP** that are outside of the DHCP allocation pool.

IMPORTANT

The CIDR ranges for networks are not adjustable after cluster installation. Red Hat does not provide direct guidance on determining the range during cluster installation because it requires careful consideration of the number of created pods per namespace.

19.4.11.7. Sample customized install-config.yaml file for RHOSP with Kuryr

To deploy with Kuryr SDN instead of the default OpenShift SDN, you must modify the **install-config.yaml** file to include **Kuryr** as the desired **networking.networkType** and proceed with the default OpenShift Container Platform SDN installation steps. This sample **install-config.yaml** demonstrates all of the possible Red Hat OpenStack Platform (RHOSP) customization options.

IMPORTANT

This sample file is provided for reference only. You must obtain your **install-config.yaml** file by using the installation program.

```
apiVersion: v1
baseDomain: example.com
controlPlane:
  name: master
  platform: {}
  replicas: 3
compute:
- name: worker
  platform:
    openstack:
      type: ml.large
  replicas: 3
metadata:
  name: example
networking:
  clusterNetwork:
  - cidr: 10.128.0.0/14
    hostPrefix: 23
  machineNetwork:
```

```
  - cidr: 10.0.0.0/16
  serviceNetwork:
  - 172.30.0.0/16 1
  networkType: Kuryr
platform:
  openstack:
    cloud: mycloud
    externalNetwork: external
    computeFlavor: m1.xlarge
    apiFloatingIP: 128.0.0.1
    trunkSupport: true 2
    octaviaSupport: true 3
pullSecret: '{"auths": ...}'
sshKey: ssh-ed25519 AAAA...
```

1 The Amphora Octavia driver creates two ports per load balancer. As a result, the service subnet that the installer creates is twice the size of the CIDR that is specified as the value of the **serviceNetwork** property. The larger range is required to prevent IP address conflicts.

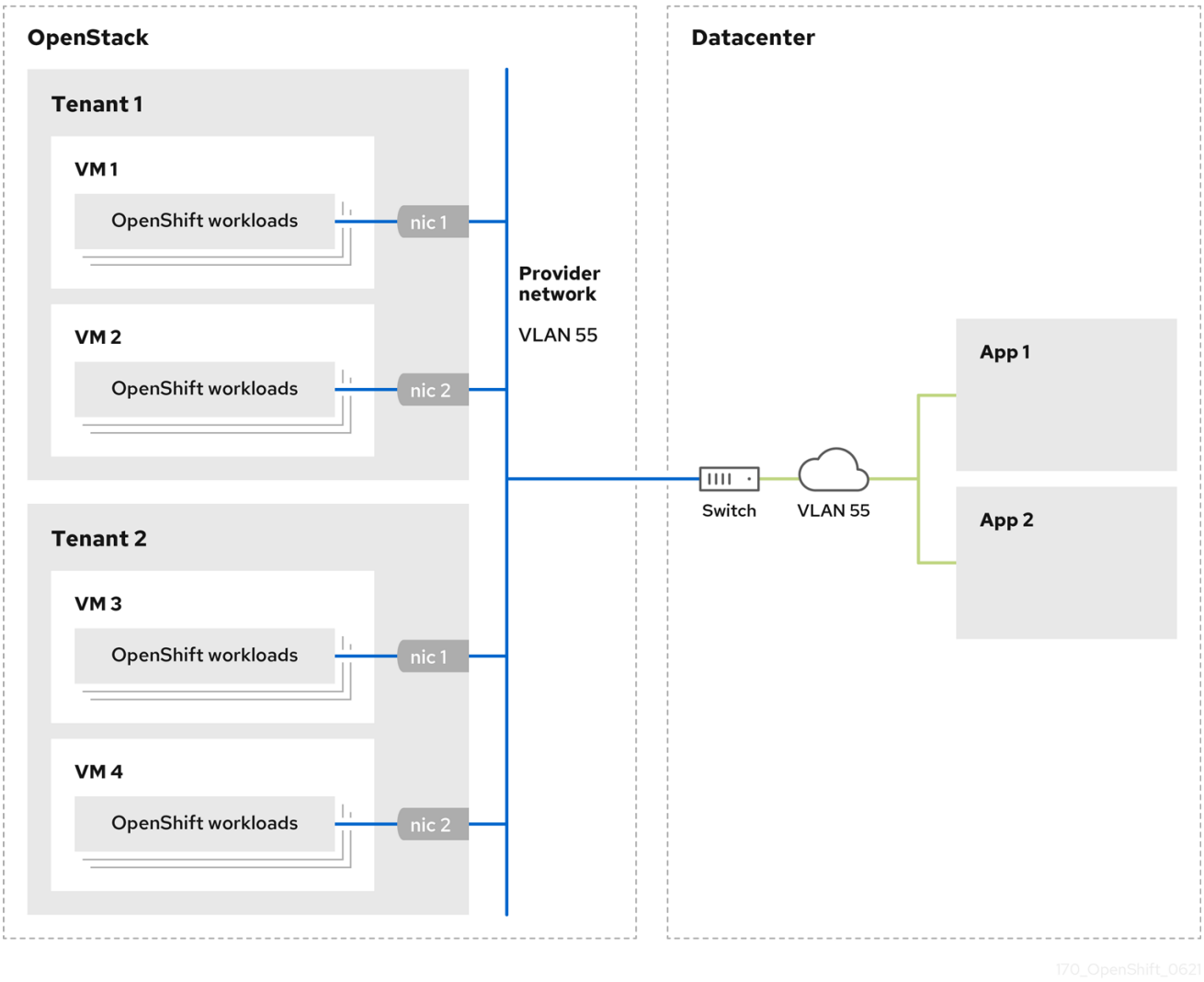
2 3 Both **trunkSupport** and **octaviaSupport** are automatically discovered by the installer, so there is no need to set them. But if your environment does not meet both requirements, Kuryr SDN will not properly work. Trunks are needed to connect the pods to the RHOSP network and Octavia is required to create the OpenShift Container Platform services.

19.4.11.8. Cluster deployment on RHOSP provider networks

You can deploy your OpenShift Container Platform clusters on Red Hat OpenStack Platform (RHOSP) with a primary network interface on a provider network. Provider networks are commonly used to give projects direct access to a public network that can be used to reach the internet. You can also share provider networks among projects as part of the network creation process.

RHOSP provider networks map directly to an existing physical network in the data center. A RHOSP administrator must create them.

In the following example, OpenShift Container Platform workloads are connected to a data center by using a provider network:



OpenShift Container Platform clusters that are installed on provider networks do not require tenant networks or floating IP addresses. The installer does not create these resources during installation.

Example provider network types include flat (untagged) and VLAN (802.1Q tagged).

NOTE

A cluster can support as many provider network connections as the network type allows. For example, VLAN networks typically support up to 4096 connections.

You can learn more about provider and tenant networks in the RHOSP documentation.

19.4.11.8.1. RHOSP provider network requirements for cluster installation

Before you install an OpenShift Container Platform cluster, your Red Hat OpenStack Platform (RHOSP) deployment and provider network must meet a number of conditions:

- The RHOSP networking service (Neutron) is enabled and accessible through the RHOSP networking API.
- The RHOSP networking service has the port security and allowed address pairs extensions enabled.

- The provider network can be shared with other tenants.

  TIP

  Use the **openstack network create** command with the **--share** flag to create a network that can be shared.

- The RHOSP project that you use to install the cluster must own the provider network, as well as an appropriate subnet.

  TIP

  To create a network for a project that is named "openshift," enter the following command

  ```
  $ openstack network create --project openshift
  ```

  To create a subnet for a project that is named "openshift," enter the following command

  ```
  $ openstack subnet create --project openshift
  ```

  To learn more about creating networks on RHOSP, read the provider networks documentation.

  If the cluster is owned by the **admin** user, you must run the installer as that user to create ports on the network.

  IMPORTANT

  Provider networks must be owned by the RHOSP project that is used to create the cluster. If they are not, the RHOSP Compute service (Nova) cannot request a port from that network.

- Verify that the provider network can reach the RHOSP metadata service IP address, which is **169.254.169.254** by default.
  Depending on your RHOSP SDN and networking service configuration, you might need to provide the route when you create the subnet. For example:

  ```
  $ openstack subnet create --dhcp --host-route
  destination=169.254.169.254/32,gateway=192.0.2.2 ...
  ```

- Optional: To secure the network, create role-based access control (RBAC) rules that limit network access to a single project.

19.4.11.8.2. Deploying a cluster that has a primary interface on a provider network

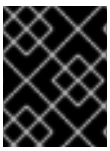
You can deploy an OpenShift Container Platform cluster that has its primary network interface on an Red Hat OpenStack Platform (RHOSP) provider network.

Prerequisites

- Your Red Hat OpenStack Platform (RHOSP) deployment is configured as described by "RHOSP provider network requirements for cluster installation".

Procedure

1. In a text editor, open the **install-config.yaml** file.
2. Set the value of the **platform.openstack.apiVIP** property to the IP address for the API VIP.
3. Set the value of the **platform.openstack.ingressVIP** property to the IP address for the Ingress VIP.
4. Set the value of the **platform.openstack.machinesSubnet** property to the UUID of the provider network subnet.
5. Set the value of the **networking.machineNetwork.cidr** property to the CIDR block of the provider network subnet.



IMPORTANT

The **platform.openstack.apiVIP** and **platform.openstack.ingressVIP** properties must both be unassigned IP addresses from the **networking.machineNetwork.cidr** block.

Section of an installation configuration file for a cluster that relies on a RHOSP provider network

```
...
platform:
  openstack:
    apiVIP: 192.0.2.13
    ingressVIP: 192.0.2.23
    machinesSubnet: fa806b2f-ac49-4bce-b9db-124bc64209bf
    # ...
networking:
  machineNetwork:
  - cidr: 192.0.2.0/24
```

WARNING

You cannot set the **platform.openstack.externalNetwork** or **platform.openstack.externalDNS** parameters while using a provider network for the primary network interface.

When you deploy the cluster, the installer uses the **install-config.yaml** file to deploy the cluster on the provider network.

TIP

You can add additional networks, including provider networks, to the **platform.openstack.additionalNetworkIDs** list.

After you deploy your cluster, you can attach pods to additional networks. For more information, see Understanding multiple networks.

19.4.11.9. Kuryr ports pools

A Kuryr ports pool maintains a number of ports on standby for pod creation.

Keeping ports on standby minimizes pod creation time. Without ports pools, Kuryr must explicitly request port creation or deletion whenever a pod is created or deleted.

The Neutron ports that Kuryr uses are created in subnets that are tied to namespaces. These pod ports are also added as subports to the primary port of OpenShift Container Platform cluster nodes.

Because Kuryr keeps each namespace in a separate subnet, a separate ports pool is maintained for each namespace-worker pair.

Prior to installing a cluster, you can set the following parameters in the **cluster-network-03-config.yml** manifest file to configure ports pool behavior:

- The **enablePortPoolsPrepopulation** parameter controls pool prepopulation, which forces Kuryr to add Neutron ports to the pools when the first pod that is configured to use the dedicated network for pods is created in a namespace. The default value is **false**.
- The **poolMinPorts** parameter is the minimum number of free ports that are kept in the pool. The default value is **1**.
- The **poolMaxPorts** parameter is the maximum number of free ports that are kept in the pool. A value of **0** disables that upper bound. This is the default setting.
  If your OpenStack port quota is low, or you have a limited number of IP addresses on the pod network, consider setting this option to ensure that unneeded ports are deleted.
- The **poolBatchPorts** parameter defines the maximum number of Neutron ports that can be created at once. The default value is **3**.

19.4.11.10. Adjusting Kuryr ports pools during installation

During installation, you can configure how Kuryr manages Red Hat OpenStack Platform (RHOSP) Neutron ports to control the speed and efficiency of pod creation.

Prerequisites

- Create and modify the **install-config.yaml** file.

Procedure

1. From a command line, create the manifest files:

```
$ ./openshift-install create manifests --dir <installation_directory> 1
```

1 For **<installation_directory>**, specify the name of the directory that contains the **install-config.yaml** file for your cluster.

2. Create a file that is named **cluster-network-03-config.yml** in the **<installation_directory>/manifests/** directory:

```
$ touch <installation_directory>/manifests/cluster-network-03-config.yml 1
```

1 For **<installation_directory>**, specify the directory name that contains the **manifests/** directory for your cluster.

After creating the file, several network configuration files are in the **manifests/** directory, as shown:

```
$ ls <installation_directory>/manifests/cluster-network-*
```

Example output

```
cluster-network-01-crd.yml
cluster-network-02-config.yml
cluster-network-03-config.yml
```

3. Open the **cluster-network-03-config.yml** file in an editor, and enter a custom resource (CR) that describes the Cluster Network Operator configuration that you want:

```
$ oc edit networks.operator.openshift.io cluster
```

4. Edit the settings to meet your requirements. The following file is provided as an example:

```
apiVersion: operator.openshift.io/v1
kind: Network
metadata:
  name: cluster
spec:
  clusterNetwork:
  - cidr: 10.128.0.0/14
    hostPrefix: 23
  serviceNetwork:
  - 172.30.0.0/16
  defaultNetwork:
    type: Kuryr
    kuryrConfig:
      enablePortPoolsPrepopulation: false 1
      poolMinPorts: 1 2
      poolBatchPorts: 3 3
      poolMaxPorts: 5 4
      openstackServiceNetwork: 172.30.0.0/15 5
```

1 Set **enablePortPoolsPrepopulation** to **true** to make Kuryr create new Neutron ports when the first pod on the network for pods is created in a namespace. This setting raises the Neutron ports quota but can reduce the time that is required to spawn pods. The default

value is **false**.

2 Kuryr creates new ports for a pool if the number of free ports in that pool is lower than the value of **poolMinPorts**. The default value is **1**.

3 **poolBatchPorts** controls the number of new ports that are created if the number of free ports is lower than the value of **poolMinPorts**. The default value is **3**.

4 If the number of free ports in a pool is higher than the value of **poolMaxPorts**, Kuryr deletes them until the number matches that value. Setting this value to **0** disables this upper bound, preventing pools from shrinking. The default value is **0**.

5 The **openStackServiceNetwork** parameter defines the CIDR range of the network from which IP addresses are allocated to RHOSP Octavia's LoadBalancers.

If this parameter is used with the Amphora driver, Octavia takes two IP addresses from this network for each load balancer: one for OpenShift and the other for VRRP connections. Because these IP addresses are managed by OpenShift Container Platform and Neutron respectively, they must come from different pools. Therefore, the value of **openStackServiceNetwork** must be at least twice the size of the value of **serviceNetwork**, and the value of **serviceNetwork** must overlap entirely with the range that is defined by **openStackServiceNetwork**.

The CNO verifies that VRRP IP addresses that are taken from the range that is defined by this parameter do not overlap with the range that is defined by the **serviceNetwork** parameter.

If this parameter is not set, the CNO uses an expanded value of **serviceNetwork** that is determined by decrementing the prefix size by 1.

5. Save the **cluster-network-03-config.yml** file, and exit the text editor.

6. Optional: Back up the **manifests/cluster-network-03-config.yml** file. The installation program deletes the **manifests/** directory while creating the cluster.

19.4.12. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the **~/.ssh/authorized_keys** list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The **./openshift-install gather** command also requires the SSH public key to be in place on the cluster nodes.

IMPORTANT

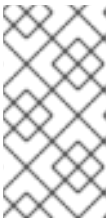
Do not skip this procedure in production environments, where disaster recovery and debugging is required.

Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N '' -f <path>/<file_name> 1
```

1 Specify the path and file name, such as ~/**.ssh/id_ed25519**, of the new SSH key. If you have an existing key pair, ensure your public key is in the your ~/**.ssh** directory.



NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS validated or Modules In Process cryptographic libraries on the **x86_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the ~/**.ssh/id_ed25519.pub** public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the **./openshift-install gather** command.

NOTE

On some distributions, default SSH private key identities such as ~/**.ssh/id_rsa** and ~/**.ssh/id_dsa** are managed automatically.

a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

Example output

```
Agent pid 31874
```

NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

1 Specify the path and file name for your SSH private key, such as **~/.ssh/id_ed25519**

Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

19.4.13. Enabling access to the environment

At deployment, all OpenShift Container Platform machines are created in a Red Hat OpenStack Platform (RHOSP)-tenant network. Therefore, they are not accessible directly in most RHOSP deployments.

You can configure OpenShift Container Platform API and application access by using floating IP addresses (FIPs) during installation. You can also complete an installation without configuring FIPs, but the installer will not configure a way to reach the API or applications externally.

19.4.13.1. Enabling access with floating IP addresses

Create floating IP (FIP) addresses for external access to the OpenShift Container Platform API and cluster applications.

Procedure

1. Using the Red Hat OpenStack Platform (RHOSP) CLI, create the API FIP:

```
$ openstack floating ip create --description "API <cluster_name>.<base_domain>"
<external_network>
```

2. Using the Red Hat OpenStack Platform (RHOSP) CLI, create the apps, or Ingress, FIP:

```
$ openstack floating ip create --description "Ingress <cluster_name>.<base_domain>"
<external_network>
```

3. Add records that follow these patterns to your DNS server for the API and Ingress FIPs:

```
api.<cluster_name>.<base_domain>.  IN  A  <API_FIP>
*.apps.<cluster_name>.<base_domain>. IN  A <apps_FIP>
```

NOTE

If you do not control the DNS server, you can access the cluster by adding the cluster domain names such as the following to your **/etc/hosts** file:

- **<api_floating_ip> api.<cluster_name>.<base_domain>**
- **<application_floating_ip> grafana-openshift-monitoring.apps.<cluster_name>.<base_domain>**
- **<application_floating_ip> prometheus-k8s-openshift-monitoring.apps.<cluster_name>.<base_domain>**
- **<application_floating_ip> oauth-openshift.apps.<cluster_name>.<base_domain>**
- **<application_floating_ip> console-openshift-console.apps.<cluster_name>.<base_domain>**
- **application_floating_ip integrated-oauth-server-openshift-authentication.apps.<cluster_name>.<base_domain>**

The cluster domain names in the **/etc/hosts** file grant access to the web console and the monitoring interface of your cluster locally. You can also use the **kubectl** or **oc**. You can access the user applications by using the additional entries pointing to the <application_floating_ip>. This action makes the API and applications accessible to only you, which is not suitable for production deployment, but does allow installation for development and testing.

4. Add the FIPs to the **install-config.yaml** file as the values of the following parameters:
   - **platform.openstack.ingressFloatingIP**
   - **platform.openstack.apiFloatingIP**

If you use these values, you must also enter an external network as the value of the **platform.openstack.externalNetwork** parameter in the **install-config.yaml** file.

TIP

You can make OpenShift Container Platform resources available outside of the cluster by assigning a floating IP address and updating your firewall configuration.

19.4.13.2. Completing installation without floating IP addresses

You can install OpenShift Container Platform on Red Hat OpenStack Platform (RHOSP) without providing floating IP addresses.

In the **install-config.yaml** file, do not define the following parameters:

- **platform.openstack.ingressFloatingIP**
- **platform.openstack.apiFloatingIP**

If you cannot provide an external network, you can also leave **platform.openstack.externalNetwork** blank. If you do not provide a value for **platform.openstack.externalNetwork**, a router is not created for

you, and, without additional action, the installer will fail to retrieve an image from Glance. You must configure external connectivity on your own.

If you run the installer from a system that cannot reach the cluster API due to a lack of floating IP addresses or name resolution, installation fails. To prevent installation failure in these cases, you can use a proxy network or run the installer from a system that is on the same network as your machines.

NOTE

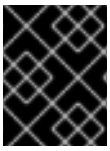
You can enable name resolution by creating DNS records for the API and Ingress ports. For example:

```
api.<cluster_name>.<base_domain>.  IN  A  <api_port_IP>
*.apps.<cluster_name>.<base_domain>. IN  A <ingress_port_IP>
```

If you do not control the DNS server, you can add the record to your **/etc/hosts** file. This action makes the API accessible to only you, which is not suitable for production deployment but does allow installation for development and testing.

19.4.14. Deploying the cluster

You can install OpenShift Container Platform on a compatible cloud platform.



IMPORTANT

You can run the **create cluster** command of the installation program only once, during initial installation.

Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.

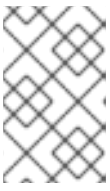
Procedure

- Change to the directory that contains the installation program and initialize the cluster deployment:

```
$ ./openshift-install create cluster --dir <installation_directory> \ 1
    --log-level=info 2
```

1 For **<installation_directory>**, specify the location of your customized **./install-config.yaml** file.

2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.



NOTE

If the cloud provider account that you configured on your host does not have sufficient permissions to deploy the cluster, the installation process stops, and the missing permissions are displayed.

Verification

When the cluster deployment completes successfully:

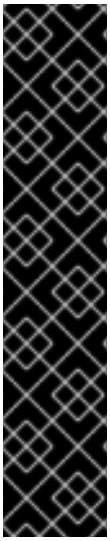
- The terminal displays directions for accessing your cluster, including a link to the web console and credentials for the **kubeadmin** user.
- Credential information also outputs to **<installation_directory>/.openshift_install.log**.

IMPORTANT

Do not delete the installation program or the files that the installation program creates. Both are required to delete the cluster.

Example output

```
...
INFO Install complete!
INFO To access the cluster as the system:admin user when using 'oc', run 'export
KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
INFO Access the OpenShift web-console here: https://console-openshift-
console.apps.mycluster.example.com
INFO Login to the console with user: "kubeadmin", and password: "password"
INFO Time elapsed: 36m22s
```



IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

19.4.15. Verifying cluster status

You can verify your OpenShift Container Platform cluster's status during or after installation.

Procedure

1. In the cluster environment, export the administrator's kubeconfig file:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

1. For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server.

2. View the control plane and compute machines created after a deployment:

```
$ oc get nodes
```

3. View your cluster's version:

```
$ oc get clusterversion
```

4. View your Operators' status:

```
$ oc get clusteroperator
```

5. View all running pods in the cluster:

```
$ oc get pods -A
```

19.4.16. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

Example output

```
system:admin
```

Additional resources

- See Accessing the web console for more details about accessing and understanding the OpenShift Container Platform web console.

19.4.17. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.11, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to OpenShift Cluster Manager Hybrid Cloud Console.

After you confirm that your OpenShift Cluster Manager Hybrid Cloud Console inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, use subscription watch to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

Additional resources

- See About remote health monitoring for more information about the Telemetry service

19.4.18. Next steps

- Customize your cluster.
- If necessary, you can opt out of remote health reporting .
- If you need to enable external access to node ports, configure ingress cluster traffic by using a node port.
- If you did not configure RHOSP to accept application traffic over floating IP addresses, configure RHOSP access with floating IP addresses .

19.5. INSTALLING A CLUSTER ON OPENSTACK ON YOUR OWN INFRASTRUCTURE

In OpenShift Container Platform version 4.11, you can install a cluster on Red Hat OpenStack Platform (RHOSP) that runs on user-provisioned infrastructure.

Using your own infrastructure allows you to integrate your cluster with existing infrastructure and modifications. The process requires more labor on your part than installer-provisioned installations, because you must create all RHOSP resources, like Nova servers, Neutron ports, and security groups. However, Red Hat provides Ansible playbooks to help you in the deployment process.

19.5.1. Prerequisites

- You reviewed details about the OpenShift Container Platform installation and update processes.
- You read the documentation on selecting a cluster installation method and preparing it for users.
- You verified that OpenShift Container Platform 4.11 is compatible with your RHOSP version by using the Supported platforms for OpenShift clusters section. You can also compare platform support across different versions by viewing the OpenShift Container Platform on RHOSP support matrix.

- You have an RHOSP account where you want to install OpenShift Container Platform.
- You understand performance and scalability practices for cluster scaling, control plane sizing, and etcd. For more information, see Recommended host practices.
- On the machine from which you run the installation program, you have:
  - A single directory in which you can keep the files you create during the installation process
  - Python 3

19.5.2. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.11, you require access to the internet to install your cluster.

You must have internet access to:

- Access OpenShift Cluster Manager Hybrid Cloud Console to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access Quay.io to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.

IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

19.5.3. Resource guidelines for installing OpenShift Container Platform on RHOSP

To support an OpenShift Container Platform installation, your Red Hat OpenStack Platform (RHOSP) quota must meet the following requirements:

Table 19.13. Recommended resources for a default OpenShift Container Platform cluster on RHOSP

Resource	Value
Floating IP addresses	3
Ports	15
Routers	1
Subnets	1
RAM	88 GB

Resource	Value
vCPUs	22
Volume storage	275 GB
Instances	7
Security groups	3
Security group rules	60
Server groups	2 - plus 1 for each additional availability zone in each machine pool

A cluster might function with fewer than recommended resources, but its performance is not guaranteed.

IMPORTANT

If RHOSP object storage (Swift) is available and operated by a user account with the **swiftoperator** role, it is used as the default backend for the OpenShift Container Platform image registry. In this case, the volume storage requirement is 175 GB. Swift space requirements vary depending on the size of the image registry.

NOTE

By default, your security group and security group rule quotas might be low. If you encounter problems, run **openstack quota set --secgroups 3 --secgroup-rules 60 <project>** as an administrator to increase them.

An OpenShift Container Platform deployment comprises control plane machines, compute machines, and a bootstrap machine.

19.5.3.1. Control plane machines

By default, the OpenShift Container Platform installation process creates three control plane machines.

Each machine requires:

- An instance from the RHOSP quota
- A port from the RHOSP quota
- A flavor with at least 16 GB memory and 4 vCPUs
- At least 100 GB storage space from the RHOSP quota

19.5.3.2. Compute machines

By default, the OpenShift Container Platform installation process creates three compute machines.

Each machine requires:

- An instance from the RHOSP quota
- A port from the RHOSP quota
- A flavor with at least 8 GB memory and 2 vCPUs
- At least 100 GB storage space from the RHOSP quota

TIP

Compute machines host the applications that you run on OpenShift Container Platform; aim to run as many as you can.

19.5.3.3. Bootstrap machine

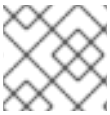
During installation, a bootstrap machine is temporarily provisioned to stand up the control plane. After the production control plane is ready, the bootstrap machine is deprovisioned.

The bootstrap machine requires:

- An instance from the RHOSP quota
- A port from the RHOSP quota
- A flavor with at least 16 GB memory and 4 vCPUs
- At least 100 GB storage space from the RHOSP quota

19.5.4. Downloading playbook dependencies

The Ansible playbooks that simplify the installation process on user-provisioned infrastructure require several Python modules. On the machine where you will run the installer, add the modules' repositories and then download them.



NOTE

These instructions assume that you are using Red Hat Enterprise Linux (RHEL) 8.

Prerequisites

- Python 3 is installed on your machine.

Procedure

1. On a command line, add the repositories:
   a. Register with Red Hat Subscription Manager:

```
$ sudo subscription-manager register # If not done already
```

   b. Pull the latest subscription data:

```
$ sudo subscription-manager attach --pool=$YOUR_POOLID # If not done already
```

-

c. Disable the current repositories:

```
$ sudo subscription-manager repos --disable=* # If not done already
```

d. Add the required repositories:

```
$ sudo subscription-manager repos \
  --enable=rhel-8-for-x86_64-baseos-rpms \
  --enable=openstack-16-tools-for-rhel-8-x86_64-rpms \
  --enable=ansible-2.9-for-rhel-8-x86_64-rpms \
  --enable=rhel-8-for-x86_64-appstream-rpms
```

2. Install the modules:

```
$ sudo yum install python3-openstackclient ansible python3-openstacksdk python3-netaddr
```

3. Ensure that the **python** command points to **python3**:

```
$ sudo alternatives --set python /usr/bin/python3
```

19.5.5. Downloading the installation playbooks

Download Ansible playbooks that you can use to install OpenShift Container Platform on your own Red Hat OpenStack Platform (RHOSP) infrastructure.

Prerequisites

- The curl command-line tool is available on your machine.

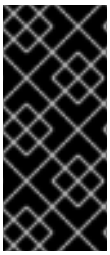
Procedure

- To download the playbooks to your working directory, run the following script from a command line:

```
$ xargs -n 1 curl -O <<< '
    https://raw.githubusercontent.com/openshift/installer/release-
4.11/upi/openstack/bootstrap.yaml
    https://raw.githubusercontent.com/openshift/installer/release-
4.11/upi/openstack/common.yaml
    https://raw.githubusercontent.com/openshift/installer/release-
4.11/upi/openstack/compute-nodes.yaml
    https://raw.githubusercontent.com/openshift/installer/release-4.11/upi/openstack/control-
plane.yaml
    https://raw.githubusercontent.com/openshift/installer/release-
4.11/upi/openstack/inventory.yaml
    https://raw.githubusercontent.com/openshift/installer/release-
4.11/upi/openstack/network.yaml
    https://raw.githubusercontent.com/openshift/installer/release-
4.11/upi/openstack/security-groups.yaml
    https://raw.githubusercontent.com/openshift/installer/release-4.11/upi/openstack/down-
bootstrap.yaml
    https://raw.githubusercontent.com/openshift/installer/release-4.11/upi/openstack/down-
```

```
compute-nodes.yaml
    https://raw.githubusercontent.com/openshift/installer/release-4.11/upi/openstack/down-control-plane.yaml
    https://raw.githubusercontent.com/openshift/installer/release-4.11/upi/openstack/down-load-balancers.yaml
    https://raw.githubusercontent.com/openshift/installer/release-4.11/upi/openstack/down-network.yaml
    https://raw.githubusercontent.com/openshift/installer/release-4.11/upi/openstack/down-security-groups.yaml
    https://raw.githubusercontent.com/openshift/installer/release-4.11/upi/openstack/down-containers.yaml'
```

The playbooks are downloaded to your machine.



IMPORTANT

During the installation process, you can modify the playbooks to configure your deployment.

Retain all playbooks for the life of your cluster. You must have the playbooks to remove your OpenShift Container Platform cluster from RHOSP.

IMPORTANT

You must match any edits you make in the **bootstrap.yaml**, **compute-nodes.yaml**, **control-plane.yaml**, **network.yaml**, and **security-groups.yaml** files to the corresponding playbooks that are prefixed with **down-**. For example, edits to the **bootstrap.yaml** file must be reflected in the **down-bootstrap.yaml** file, too. If you do not edit both files, the supported cluster removal process will fail.

19.5.6. Obtaining the installation program

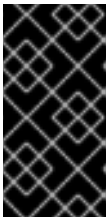
Before you install OpenShift Container Platform, download the installation file on a local computer.

Prerequisites

- You have a computer that runs Linux or macOS, with 500 MB of local disk space.

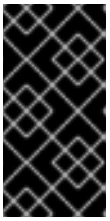
Procedure

1. Access the Infrastructure Provider page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program that corresponds with your host operating system and architecture, and place the file in the directory where you will store the installation configuration files.



IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.



IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation pull secret from the Red Hat OpenShift Cluster Manager . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

19.5.7. Generating a key pair for cluster node SSH access

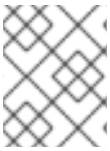
During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the **~/.ssh/authorized_keys** list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The **./openshift-install gather** command also requires the SSH public key to be in place on the cluster nodes.

IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.



NOTE

You must use a local key, not one that you configured with platform-specific approaches such as AWS key pairs.

Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N '' -f <path>/<file_name> 1
```

1 Specify the path and file name, such as ~/**.ssh/id_ed25519**, of the new SSH key. If you have an existing key pair, ensure your public key is in the your ~/**.ssh** directory.

NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS validated or Modules In Process cryptographic libraries on the **x86_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the ~/**.ssh/id_ed25519.pub** public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the **./openshift-install gather** command.

NOTE

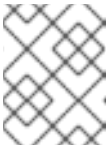
On some distributions, default SSH private key identities such as ~/**.ssh/id_rsa** and ~/**.ssh/id_dsa** are managed automatically.

a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

Example output

```
Agent pid 31874
```



NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

1 Specify the path and file name for your SSH private key, such as **~/.ssh/id_ed25519**

Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

19.5.8. Creating the Red Hat Enterprise Linux CoreOS (RHCOS) image

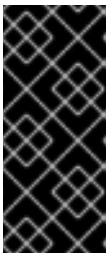
The OpenShift Container Platform installation program requires that a Red Hat Enterprise Linux CoreOS (RHCOS) image be present in the Red Hat OpenStack Platform (RHOSP) cluster. Retrieve the latest RHCOS image, then upload it using the RHOSP CLI.

Prerequisites

- The RHOSP CLI is installed.

Procedure

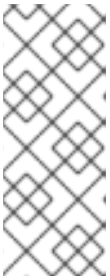
1. Log in to the Red Hat Customer Portal's Product Downloads page.
2. Under **Version**, select the most recent release of OpenShift Container Platform 4.11 for Red Hat Enterprise Linux (RHEL) 8.



IMPORTANT

The RHCOS images might not change with every release of OpenShift Container Platform. You must download images with the highest version that is less than or equal to the OpenShift Container Platform version that you install. Use the image versions that match your OpenShift Container Platform version if they are available.

3. Download the *Red Hat Enterprise Linux CoreOS (RHCOS) - OpenStack Image (QCOW)* .
4. Decompress the image.



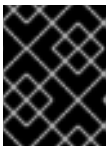
NOTE

You must decompress the RHOSP image before the cluster can use it. The name of the downloaded file might not contain a compression extension, like **.gz** or **.tgz**. To find out if or how the file is compressed, in a command line, enter:

```
$ file <name_of_downloaded_file>
```

5. From the image that you downloaded, create an image that is named **rhcos** in your cluster by using the RHOSP CLI:

```
$ openstack image create --container-format=bare --disk-format=qcow2 --file rhcos-
${RHCOS_VERSION}-openstack.qcow2 rhcos
```



IMPORTANT

Depending on your RHOSP environment, you might be able to upload the image in either **.raw** or **.qcow2** formats. If you use Ceph, you must use the **.raw** format.

WARNING

If the installation program finds multiple images with the same name, it chooses one of them at random. To avoid this behavior, create unique names for resources in RHOSP.

After you upload the image to RHOSP, it is usable in the installation process.

19.5.9. Verifying external network access

The OpenShift Container Platform installation process requires external network access. You must provide an external network value to it, or deployment fails. Before you begin the process, verify that a network with the external router type exists in Red Hat OpenStack Platform (RHOSP).

Prerequisites

- Configure OpenStack's networking service to have DHCP agents forward instances' DNS queries

Procedure

1. Using the RHOSP CLI, verify the name and ID of the 'External' network:

```
$ openstack network list --long -c ID -c Name -c "Router Type"
```

Example output

```
+--------------------------------------+---------------+-------------+
| ID                                   | Name          | Router Type |
+--------------------------------------+---------------+-------------+
| 148a8023-62a7-4672-b018-003462f8d7dc | public_network | External    |
+--------------------------------------+---------------+-------------+
```

A network with an external router type appears in the network list. If at least one does not, see Creating a default floating IP network and Creating a default provider network .

NOTE

If the Neutron trunk service plugin is enabled, a trunk port is created by default. For more information, see Neutron trunk port .

19.5.10. Enabling access to the environment

At deployment, all OpenShift Container Platform machines are created in a Red Hat OpenStack Platform (RHOSP)-tenant network. Therefore, they are not accessible directly in most RHOSP deployments.

You can configure OpenShift Container Platform API and application access by using floating IP addresses (FIPs) during installation. You can also complete an installation without configuring FIPs, but the installer will not configure a way to reach the API or applications externally.

19.5.10.1. Enabling access with floating IP addresses

Create floating IP (FIP) addresses for external access to the OpenShift Container Platform API, cluster applications, and the bootstrap process.

Procedure

1. Using the Red Hat OpenStack Platform (RHOSP) CLI, create the API FIP:

```
$ openstack floating ip create --description "API <cluster_name>.<base_domain>"
<external_network>
```

2. Using the Red Hat OpenStack Platform (RHOSP) CLI, create the apps, or Ingress, FIP:

```
$ openstack floating ip create --description "Ingress <cluster_name>.<base_domain>"
<external_network>
```

3. By using the Red Hat OpenStack Platform (RHOSP) CLI, create the bootstrap FIP:

```
$ openstack floating ip create --description "bootstrap machine" <external_network>
```

4. Add records that follow these patterns to your DNS server for the API and Ingress FIPs:

```
api.<cluster_name>.<base_domain>.  IN  A  <API_FIP>
*.apps.<cluster_name>.<base_domain>. IN  A <apps_FIP>
```

NOTE

If you do not control the DNS server, you can access the cluster by adding the cluster domain names such as the following to your **/etc/hosts** file:

- **<api_floating_ip> api.<cluster_name>.<base_domain>**
- **<application_floating_ip> grafana-openshift-monitoring.apps.<cluster_name>.<base_domain>**
- **<application_floating_ip> prometheus-k8s-openshift-monitoring.apps.<cluster_name>.<base_domain>**
- **<application_floating_ip> oauth-openshift.apps.<cluster_name>.<base_domain>**
- **<application_floating_ip> console-openshift-console.apps.<cluster_name>.<base_domain>**
- **application_floating_ip integrated-oauth-server-openshift-authentication.apps.<cluster_name>.<base_domain>**

The cluster domain names in the **/etc/hosts** file grant access to the web console and the monitoring interface of your cluster locally. You can also use the **kubectl** or **oc**. You can access the user applications by using the additional entries pointing to the <application_floating_ip>. This action makes the API and applications accessible to only you, which is not suitable for production deployment, but does allow installation for development and testing.

5. Add the FIPs to the **inventory.yaml** file as the values of the following variables:
   - **os_api_fip**
   - **os_bootstrap_fip**
   - **os_ingress_fip**

If you use these values, you must also enter an external network as the value of the **os_external_network** variable in the **inventory.yaml** file.

TIP

You can make OpenShift Container Platform resources available outside of the cluster by assigning a floating IP address and updating your firewall configuration.

19.5.10.2. Completing installation without floating IP addresses

You can install OpenShift Container Platform on Red Hat OpenStack Platform (RHOSP) without providing floating IP addresses.

In the **inventory.yaml** file, do not define the following variables:

- **os_api_fip**
- **os_bootstrap_fip**

- **os_ingress_fip**

If you cannot provide an external network, you can also leave **os_external_network** blank. If you do not provide a value for **os_external_network**, a router is not created for you, and, without additional action, the installer will fail to retrieve an image from Glance. Later in the installation process, when you create network resources, you must configure external connectivity on your own.

If you run the installer with the **wait-for** command from a system that cannot reach the cluster API due to a lack of floating IP addresses or name resolution, installation fails. To prevent installation failure in these cases, you can use a proxy network or run the installer from a system that is on the same network as your machines.

NOTE

You can enable name resolution by creating DNS records for the API and Ingress ports. For example:

```
api.<cluster_name>.<base_domain>.  IN  A  <api_port_IP>
*.apps.<cluster_name>.<base_domain>. IN  A <ingress_port_IP>
```

If you do not control the DNS server, you can add the record to your **/etc/hosts** file. This action makes the API accessible to only you, which is not suitable for production deployment but does allow installation for development and testing.

19.5.11. Defining parameters for the installation program

The OpenShift Container Platform installation program relies on a file that is called **clouds.yaml**. The file describes Red Hat OpenStack Platform (RHOSP) configuration parameters, including the project name, log in information, and authorization service URLs.

Procedure

1. Create the **clouds.yaml** file:

   - If your RHOSP distribution includes the Horizon web UI, generate a **clouds.yaml** file in it.

IMPORTANT

Remember to add a password to the **auth** field. You can also keep secrets in a separate file from **clouds.yaml**. OpenShift Container Platform does not support application credentials.

   - If your RHOSP distribution does not include the Horizon web UI, or you do not want to use Horizon, create the file yourself. For detailed information about **clouds.yaml**, see Config files in the RHOSP documentation.

```
clouds:
  shiftstack:
    auth:
      auth_url: http://10.10.14.42:5000/v3
      project_name: shiftstack
      username: <username>
      password: <password>
      user_domain_name: Default
```

```
    project_domain_name: Default
  dev-env:
    region_name: RegionOne
    auth:
      username: <username>
      password: <password>
      project_name: 'devonly'
      auth_url: 'https://10.10.14.22:5001/v2.0'
```

2. If your RHOSP installation uses self-signed certificate authority (CA) certificates for endpoint authentication:

   a. Copy the certificate authority file to your machine.

   b. Add the **cacerts** key to the **clouds.yaml** file. The value must be an absolute, non-root-accessible path to the CA certificate:

```
clouds:
  shiftstack:
    ...
    cacert: "/etc/pki/ca-trust/source/anchors/ca.crt.pem"
```

   TIP

   After you run the installer with a custom CA certificate, you can update the certificate by editing the value of the **ca-cert.pem** key in the **cloud-provider-config** keymap. On a command line, run:

```
$ oc edit configmap -n openshift-config cloud-provider-config
```

3. Place the **clouds.yaml** file in one of the following locations:

   a. The value of the **OS_CLIENT_CONFIG_FILE** environment variable

   b. The current directory

   c. A Unix-specific user configuration directory, for example **~/.config/openstack/clouds.yaml**

   d. A Unix-specific site configuration directory, for example **/etc/openstack/clouds.yaml**
   The installation program searches for **clouds.yaml** in that order.

19.5.12. Creating the installation configuration file

You can customize the OpenShift Container Platform cluster you install on Red Hat OpenStack Platform (RHOSP).

Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.
- Obtain service principal permissions at the subscription level.

Procedure

1. Create the **install-config.yaml** file.

   a. Change to the directory that contains the installation program and run the following command:

   ```
   $ ./openshift-install create install-config --dir <installation_directory> 1
   ```

   1 For **<installation_directory>**, specify the directory name to store the files that the installation program creates.

   When specifying the directory:

   - Verify that the directory has the **execute** permission. This permission is required to run Terraform binaries under the installation directory.
   - Use an empty directory. Some installation assets, such as bootstrap X.509 certificates, have short expiration intervals, therefore you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

   b. At the prompts, provide the configuration details for your cloud:

      i. Optional: Select an SSH key to use to access your cluster machines.

      NOTE

      For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

      ii. Select **openstack** as the platform to target.

      iii. Specify the Red Hat OpenStack Platform (RHOSP) external network name to use for installing the cluster.

      iv. Specify the floating IP address to use for external access to the OpenShift API.

      v. Specify a RHOSP flavor with at least 16 GB RAM to use for control plane nodes and 8 GB RAM for compute nodes.

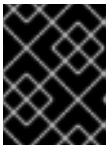
      vi. Select the base domain to deploy the cluster to. All DNS records will be sub-domains of this base and will also include the cluster name.

      vii. Enter a name for your cluster. The name must be 14 or fewer characters long.

      viii. Paste the pull secret from the Red Hat OpenShift Cluster Manager .

2. Modify the **install-config.yaml** file. You can find more information about the available parameters in the "Installation configuration parameters" section.

3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.



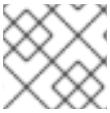
IMPORTANT

The **install-config.yaml** file is consumed during the installation process. If you want to reuse the file, you must back it up now.

You now have the file **install-config.yaml** in the directory that you specified.

19.5.13. Installation configuration parameters

Before you deploy an OpenShift Container Platform cluster, you provide parameter values to describe your account on the cloud platform that hosts your cluster and optionally customize your cluster's platform. When you create the **install-config.yaml** installation configuration file, you provide values for the required parameters through the command line. If you customize your cluster, you can modify the **install-config.yaml** file to provide more details about the platform.



NOTE

After installation, you cannot modify these parameters in the **install-config.yaml** file.

19.5.13.1. Required configuration parameters

Required installation configuration parameters are described in the following table:

Table 19.14. Required parameters

Parameter	Description	Values
apiVersion	The API version for the **install-config.yaml** content. The current version is **v1**. The installer may also support older API versions.	String
baseDomain	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the **baseDomain** and **metadata.name** parameter values that uses the **<metadata.name>.<baseDomain>** format.	A fully-qualified domain or subdomain name, such as **example.com**.
metadata	Kubernetes resource **ObjectMeta**, from which only the **name** parameter is consumed.	Object

Parameter	Description	Values
metadata.name	The name of the cluster. DNS records for the cluster are all subdomains of **{{.metadata.name}}.{{.baseDomain}}**.	String of lowercase letters, hyphens (**-**), and periods (**.**), such as **dev**. The string must be 14 characters or fewer long.
platform	The configuration for the specific platform upon which to perform the installation: **alibabacloud**, **aws**, **baremetal**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**. For additional information about **platform.<platform>** parameters, consult the table for your specific platform that follows.	Object
pullSecret	Get a pull secret from the Red Hat OpenShift Cluster Manager to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	<pre>{ "auths":{ "cloud.openshift.com":{ "auth":"b3Blb=", "email":"you@example.com" }, "quay.io":{ "auth":"b3Blb=", "email":"you@example.com" } } }</pre>

19.5.13.2. Network configuration parameters

You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

Only IPv4 addresses are supported.

NOTE

Globalnet is not supported with Red Hat OpenShift Data Foundation disaster recovery solutions. For regional disaster recovery scenarios, ensure that you use a nonoverlapping range of private IP addresses for the cluster and service networks in each cluster.

Table 19.15. Network parameters

Parameter	Description	Values
networking	The configuration for the cluster network.	Object  **NOTE** You cannot modify parameters specified by the **networking** object after installation.
networking.networkType	The cluster network provider Container Network Interface (CNI) cluster network provider to install.	Either **OpenShiftSDN** or **OVNKubernetes**. **OpenShiftSDN** is a CNI provider for all-Linux networks. **OVNKubernetes** is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is **OpenShiftSDN**.
networking.clusterNetwork	The IP address blocks for pods. The default value is **10.128.0.0/14** with a host prefix of **/23**. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: `networking:` `  clusterNetwork:` `  - cidr: 10.128.0.0/14` `    hostPrefix: 23`
networking.clusterNetwork.cidr	Required if you use **networking.clusterNetwork**. An IP address block. An IPv4 network.	An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between **0** and **32**.
networking.clusterNetwork.hostPrefix	The subnet prefix length to assign to each individual node. For example, if **hostPrefix** is set to **23** then each node is assigned a **/23** subnet out of the given **cidr**. A **hostPrefix** value of **23** provides 510 (2^(32 - 23) - 2) pod IP addresses.	A subnet prefix. The default value is **23**.
networking.serviceNetwork	The IP address block for services. The default value is **172.30.0.0/16**. The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.	An array with an IP address block in CIDR format. For example: `networking:` `  serviceNetwork:` `  - 172.30.0.0/16`

Parameter	Description	Values
networking.machineNetwork	The IP address blocks for machines. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: networking: machineNetwork: - cidr: 10.0.0.0/16
networking.machineNetwork.cidr	Required if you use **networking.machineNetwork**. An IP address block. The default value is **10.0.0.0/16** for all platforms other than libvirt. For libvirt, the default value is **192.168.126.0/24**.	An IP network block in CIDR notation. For example, **10.0.0.0/16**. **NOTE** Set the **networking.machineNetwork** to match the CIDR that the preferred NIC resides in.

19.5.13.3. Optional configuration parameters

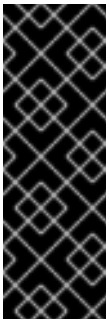
Optional installation configuration parameters are described in the following table:

Table 19.16. Optional parameters

Parameter	Description	Values
additionalTrustBundle	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String
capabilities	Controls the installation of optional core cluster components. You can reduce the footprint of your OpenShift Container Platform cluster by disabling optional components.	String array

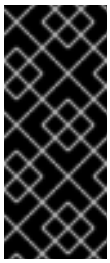
Parameter	Description	Values
capabilities.baselineCapabilitySet	Selects an initial set of optional capabilities to enable. Valid values are **None**, **v4.11** and **vCurrent**. **v4.11** enables the **baremetal** Operator, the **marketplace** Operator, and the **openshift-samples** content. **vCurrent** installs the recommended set of capabilities for the current version of OpenShift Container Platform. The default value is **vCurrent**.	String
capabilities.additionalEnabledCapabilities	Extends the set of optional capabilities beyond what you specify in **baselineCapabilitySet**. Valid values are **baremetal**, **marketplace** and **openshift-samples**. You may specify multiple capabilities in this parameter.	String array
cgroupsV2	Enables Linux control groups version 2 (cgroups v2) on specific nodes in your cluster. The OpenShift Container Platform process for enabling cgroups v2 disables all cgroup version 1 controllers and hierarchies. The OpenShift Container Platform cgroups version 2 feature is in Developer Preview and is not supported by Red Hat at this time.	**true**
compute	The configuration for the machines that comprise the compute nodes.	Array of **MachinePool** objects.
compute.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** (the default).	String

Parameter	Description	Values
compute.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  IMPORTANT If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
compute.name	Required if you use **compute**. The name of the machine pool.	**worker**
compute.platform	Required if you use **compute**. Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the **controlPlane.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
compute.replicas	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to **2**. The default value is **3**.
controlPlane	The configuration for the machines that comprise the control plane.	Array of **MachinePool** objects.
controlPlane.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** (the default).	String

Parameter	Description	Values
controlPlane.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  **IMPORTANT** If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
controlPlane.name	Required if you use **controlPlane**. The name of the machine pool.	**master**
controlPlane.platform	Required if you use **controlPlane**. Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the **compute.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
controlPlane.replicas	The number of control plane machines to provision.	The only supported value is **3**, which is the default value.

Parameter	Description	Values
credentialsMode	The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported.  **NOTE** Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the *Cloud Credential Operator* entry in the *Cluster Operators reference* content.  **NOTE** If your AWS account has service control policies (SCP) enabled, you must configure the **credentialsMode** parameter to **Mint**, **Passthrough** or **Manual**.	**Mint**, **Passthrough**, **Manual** or an empty string (**""**).
fips	Enable or disable FIPS mode. The default is **false** (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.	**false** or **true**

Parameter	Description	Values
	IMPORTANT To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture. **NOTE** If you are using Azure File storage, you cannot enable FIPS mode.	
imageContentSources	Sources and repositories for the release-image content.	Array of objects. Includes a **source** and, optionally, **mirrors**, as described in the following rows of this table.
imageContentSources.source	Required if you use **imageContentSources**. Specify the repository that users refer to, for example, in image pull specifications.	String
imageContentSources.mirrors	Specify one or more repositories that may also contain the same images.	Array of strings

Parameter	Description	Values
publish	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	**Internal** or **External**. The default value is **External**. Setting this field to **Internal** is not supported on non-cloud platforms and IBM Cloud VPC.  **IMPORTANT** If the value of the field is set to **Internal**, the cluster will become non-functional. For more information, refer to BZ#1953035.
sshKey	The SSH key to authenticate access to your cluster machines.  **NOTE** For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.	For example, **sshKey: ssh-ed25519 AAAA..**.

19.5.13.4. Additional Red Hat OpenStack Platform (RHOSP) configuration parameters

Additional RHOSP configuration parameters are described in the following table:

Table 19.17. Additional RHOSP parameters

Parameter	Description	Values
compute.platform.openstack.rootVolume.size	For compute machines, the size in gigabytes of the root volume. If you do not set this value, machines use ephemeral storage.	Integer, for example **30**.
compute.platform.openstack.rootVolume.type	For compute machines, the root volume's type.	String, for example **performance**.
controlPlane.platform.openstack.rootVolume.size	For control plane machines, the size in gigabytes of the root volume. If you do not set this value, machines use ephemeral storage.	Integer, for example **30**.
controlPlane.platform.openstack.rootVolume.type	For control plane machines, the root volume's type.	String, for example **performance**.
platform.openstack.cloud	The name of the RHOSP cloud to use from the list of clouds in the **clouds.yaml** file.	String, for example **MyCloud**.
platform.openstack.externalNetwork	The RHOSP external network name to be used for installation.	String, for example **external**.
platform.openstack.computeFlavor	The RHOSP flavor to use for control plane and compute machines. This property is deprecated. To use a flavor as the default for all machine pools, add it as the value of the **type** key in the **platform.openstack.defaultMachinePlatform** property. You can also set a flavor value for each machine pool individually.	String, for example **m1.xlarge**.

19.5.13.5. Optional RHOSP configuration parameters

Optional RHOSP configuration parameters are described in the following table:

Table 19.18. Optional RHOSP parameters

Parameter	Description	Values
compute.platform.openstack.additionalNetworkIDs	Additional networks that are associated with compute machines. Allowed address pairs are not created for additional networks.	A list of one or more UUIDs as strings. For example, **fa806b2f-ac49-4bce-b9db-124bc64209bf**.
compute.platform.openstack.additionalSecurityGroupIDs	Additional security groups that are associated with compute machines.	A list of one or more UUIDs as strings. For example, **7ee219f3-d2e9-48a1-96c2-e7429f1b0da7**.
compute.platform.openstack.zones	RHOSP Compute (Nova) availability zones (AZs) to install machines on. If this parameter is not set, the installer relies on the default settings for Nova that the RHOSP administrator configured. On clusters that use Kuryr, RHOSP Octavia does not support availability zones. Load balancers and, if you are using the Amphora provider driver, OpenShift Container Platform services that rely on Amphora VMs, are not created according to the value of this property.	A list of strings. For example, **["zone-1", "zone-2"]**.
compute.platform.openstack.rootVolume.zones	For compute machines, the availability zone to install root volumes on. If you do not set a value for this parameter, the installer selects the default availability zone.	A list of strings, for example **["zone-1", "zone-2"]**.

Parameter	Description	Values
compute.platform.openstack.serverGroupPolicy	Server group policy to apply to the group that will contain the compute machines in the pool. You cannot change server group policies or affiliations after creation. Supported options include **anti-affinity**, **soft-affinity**, and **soft-anti-affinity**. The default value is **soft-anti-affinity**. An **affinity** policy prevents migrations and therefore affects RHOSP upgrades. The **affinity** policy is not supported. If you use a strict **anti-affinity** policy, an additional RHOSP host is required during instance migration.	A server group policy to apply to the machine pool. For example, **soft-affinity**.
controlPlane.platform.openstack.additionalNetworkIDs	Additional networks that are associated with control plane machines. Allowed address pairs are not created for additional networks.	A list of one or more UUIDs as strings. For example, **fa806b2f-ac49-4bce-b9db-124bc64209bf**.
controlPlane.platform.openstack.additionalSecurityGroupIDs	Additional security groups that are associated with control plane machines.	A list of one or more UUIDs as strings. For example, **7ee219f3-d2e9-48a1-96c2-e7429f1b0da7**.

Parameter	Description	Values
controlPlane.platform.openstack.zones	RHOSP Compute (Nova) availability zones (AZs) to install machines on. If this parameter is not set, the installer relies on the default settings for Nova that the RHOSP administrator configured. On clusters that use Kuryr, RHOSP Octavia does not support availability zones. Load balancers and, if you are using the Amphora provider driver, OpenShift Container Platform services that rely on Amphora VMs, are not created according to the value of this property.	A list of strings. For example, **["zone-1", "zone-2"]**.
controlPlane.platform.openstack.rootVolume.zones	For control plane machines, the availability zone to install root volumes on. If you do not set this value, the installer selects the default availability zone.	A list of strings, for example **["zone-1", "zone-2"]**.
controlPlane.platform.openstack.serverGroupPolicy	Server group policy to apply to the group that will contain the control plane machines in the pool. You cannot change server group policies or affiliations after creation. Supported options include **anti-affinity**, **soft-affinity**, and **soft-anti-affinity**. The default value is **soft-anti-affinity**. An **affinity** policy prevents migrations, and therefore affects RHOSP upgrades. The **affinity** policy is not supported. If you use a strict **anti-affinity** policy, an additional RHOSP host is required during instance migration.	A server group policy to apply to the machine pool. For example, **soft-affinity**.

Parameter	Description	Values
platform.openstack.clusterOSImage	The location from which the installer downloads the RHCOS image. You must set this parameter to perform an installation in a restricted network.	An HTTP or HTTPS URL, optionally with an SHA-256 checksum. For example, **http://mirror.example.com/images/rhcos-43.81.201912131630.0-openstack.x86_64.qcow2.gz?sha256=ffebbd68e8a1f2a245ca19522c16c86f67f9ac8e4e0c1f0a812b068b16f7265d**. The value can also be the name of an existing Glance image, for example **my-rhcos**.
platform.openstack.clusterOSImageProperties	Properties to add to the installer-uploaded ClusterOSImage in Glance. This property is ignored if **platform.openstack.clusterOSImage** is set to an existing Glance image. You can use this property to exceed the default persistent volume (PV) limit for RHOSP of 26 PVs per node. To exceed the limit, set the **hw_scsi_model** property value to **virtio-scsi** and the **hw_disk_bus** value to **scsi**. You can also use this property to enable the QEMU guest agent by including the **hw_qemu_guest_agent** property with a value of **yes**.	A list of key-value string pairs. For example, **["hw_scsi_model": "virtio-scsi", "hw_disk_bus": "scsi"]**.
platform.openstack.defaultMachinePlatform	The default machine pool platform configuration.	<pre>{ "type": "ml.large", "rootVolume": { "size": 30, "type": "performance" } }</pre>
platform.openstack.ingressFloatingIP	An existing floating IP address to associate with the Ingress port. To use this property, you must also define the **platform.openstack.externalNetwork** property.	An IP address, for example **128.0.0.1**.

Parameter	Description	Values
platform.openstack.apiFloatingIP	An existing floating IP address to associate with the API load balancer. To use this property, you must also define the **platform.openstack.externalNetwork** property.	An IP address, for example **128.0.0.1**.
platform.openstack.externalDNS	IP addresses for external DNS servers that cluster instances use for DNS resolution.	A list of IP addresses as strings. For example, **["8.8.8.8", "192.168.1.12"]**.
platform.openstack.machinesSubnet	The UUID of a RHOSP subnet that the cluster's nodes use. Nodes and virtual IP (VIP) ports are created on this subnet. The first item in **networking.machineNetwork** must match the value of **machinesSubnet**. If you deploy to a custom subnet, you cannot specify an external DNS server to the OpenShift Container Platform installer. Instead, add DNS to the subnet in RHOSP.	A UUID as a string. For example, **fa806b2f-ac49-4bce-b9db-124bc64209bf**.

19.5.13.6. Custom subnets in RHOSP deployments

Optionally, you can deploy a cluster on a Red Hat OpenStack Platform (RHOSP) subnet of your choice. The subnet's GUID is passed as the value of **platform.openstack.machinesSubnet** in the **install-config.yaml** file.

This subnet is used as the cluster's primary subnet. By default, nodes and ports are created on it. You can create nodes and ports on a different RHOSP subnet by setting the value of the **platform.openstack.machinesSubnet** property to the subnet's UUID.

Before you run the OpenShift Container Platform installer with a custom subnet, verify that your configuration meets the following requirements:

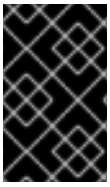
- The subnet that is used by **platform.openstack.machinesSubnet** has DHCP enabled.
- The CIDR of **platform.openstack.machinesSubnet** matches the CIDR of **networking.machineNetwork**.
- The installation program user has permission to create ports on this network, including ports with fixed IP addresses.

Clusters that use custom subnets have the following limitations:

- If you plan to install a cluster that uses floating IP addresses, the **platform.openstack.machinesSubnet** subnet must be attached to a router that is connected to the **externalNetwork** network.
- If the **platform.openstack.machinesSubnet** value is set in the **install-config.yaml** file, the installation program does not create a private network or subnet for your RHOSP machines.
- You cannot use the **platform.openstack.externalDNS** property at the same time as a custom subnet. To add DNS to a cluster that uses a custom subnet, configure DNS on the RHOSP network.

NOTE

By default, the API VIP takes x.x.x.5 and the Ingress VIP takes x.x.x.7 from your network's CIDR block. To override these default values, set values for **platform.openstack.apiVIP** and **platform.openstack.ingressVIP** that are outside of the DHCP allocation pool.



IMPORTANT

The CIDR ranges for networks are not adjustable after cluster installation. Red Hat does not provide direct guidance on determining the range during cluster installation because it requires careful consideration of the number of created pods per namespace.

19.5.13.7. Sample customized install-config.yaml file for RHOSP

This sample **install-config.yaml** demonstrates all of the possible Red Hat OpenStack Platform (RHOSP) customization options.

IMPORTANT

This sample file is provided for reference only. You must obtain your **install-config.yaml** file by using the installation program.

```
apiVersion: v1
baseDomain: example.com
controlPlane:
  name: master
  platform: {}
  replicas: 3
compute:
- name: worker
  platform:
    openstack:
      type: ml.large
  replicas: 3
metadata:
  name: example
networking:
  clusterNetwork:
  - cidr: 10.128.0.0/14
    hostPrefix: 23
  machineNetwork:
  - cidr: 10.0.0.0/16
  serviceNetwork:
```

```
  - 172.30.0.0/16
  networkType: OpenShiftSDN
platform:
  openstack:
    cloud: mycloud
    externalNetwork: external
    computeFlavor: m1.xlarge
    apiFloatingIP: 128.0.0.1
fips: false
pullSecret: '{"auths": ...}'
sshKey: ssh-ed25519 AAAA...
```

19.5.13.8. Setting a custom subnet for machines

The IP range that the installation program uses by default might not match the Neutron subnet that you create when you install OpenShift Container Platform. If necessary, update the CIDR value for new machines by editing the installation configuration file.

Prerequisites

- You have the **install-config.yaml** file that was generated by the OpenShift Container Platform installation program.

Procedure

1. On a command line, browse to the directory that contains **install-config.yaml**.
2. From that directory, either run a script to edit the **install-config.yaml** file or update the file manually:
   - To set the value by using a script, run:

```
$ python -c '
import yaml;
path = "install-config.yaml";
data = yaml.safe_load(open(path));
data["networking"]["machineNetwork"] = [{"cidr": "192.168.0.0/18"}]; 1
open(path, "w").write(yaml.dump(data, default_flow_style=False))'
```

     1 Insert a value that matches your intended Neutron subnet, e.g. **192.0.2.0/24**.

   - To set the value manually, open the file and set the value of **networking.machineCIDR** to something that matches your intended Neutron subnet.

19.5.13.9. Emptying compute machine pools

To proceed with an installation that uses your own infrastructure, set the number of compute machines in the installation configuration file to zero. Later, you create these machines manually.

Prerequisites

- You have the **install-config.yaml** file that was generated by the OpenShift Container Platform installation program.

Procedure

1. On a command line, browse to the directory that contains **install-config.yaml**.
2. From that directory, either run a script to edit the **install-config.yaml** file or update the file manually:
   - To set the value by using a script, run:

```
$ python -c '
import yaml;
path = "install-config.yaml";
data = yaml.safe_load(open(path));
data["compute"][0]["replicas"] = 0;
open(path, "w").write(yaml.dump(data, default_flow_style=False))'
```

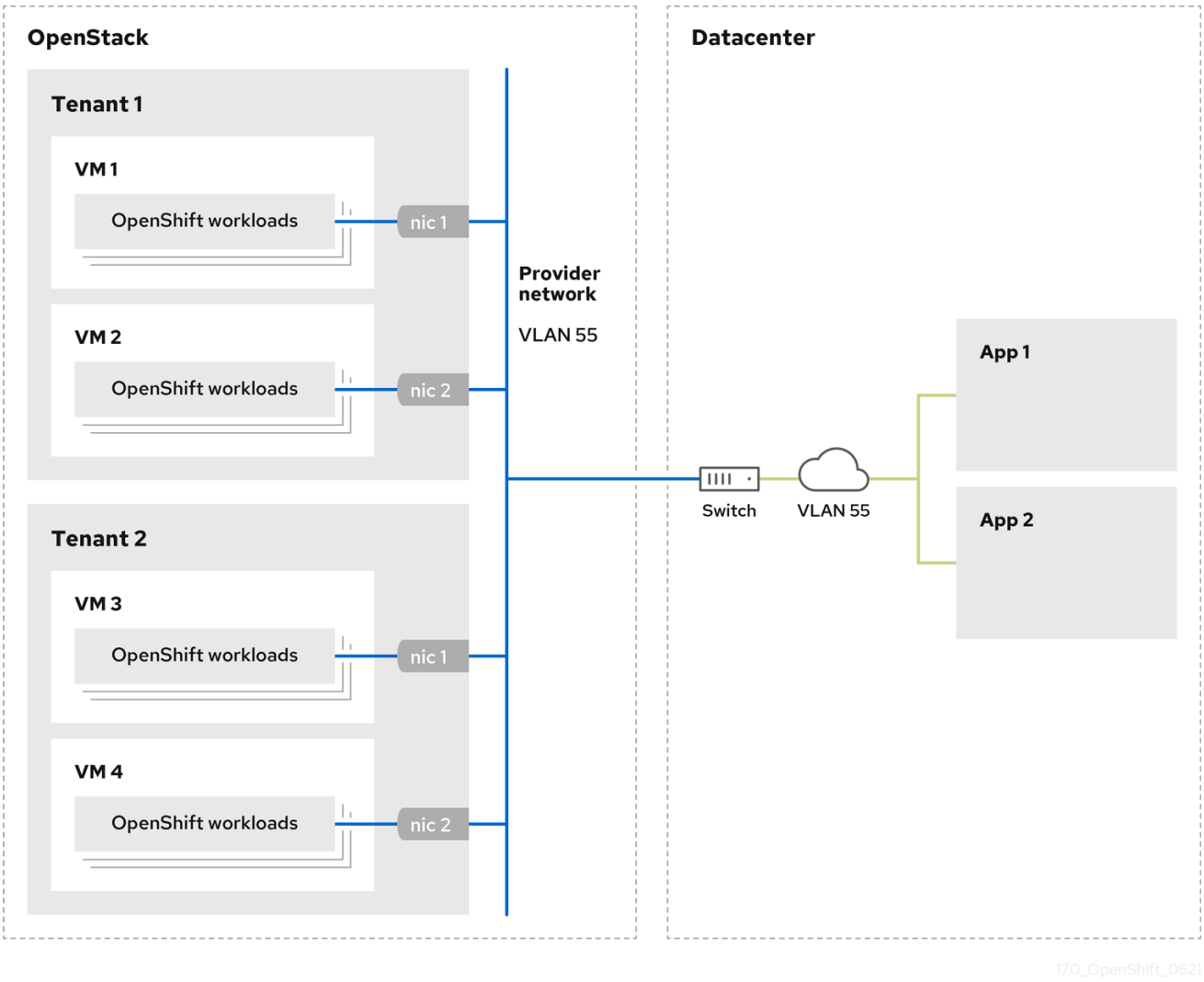
   - To set the value manually, open the file and set the value of **compute.<first entry>.replicas** to **0**.

19.5.13.10. Cluster deployment on RHOSP provider networks

You can deploy your OpenShift Container Platform clusters on Red Hat OpenStack Platform (RHOSP) with a primary network interface on a provider network. Provider networks are commonly used to give projects direct access to a public network that can be used to reach the internet. You can also share provider networks among projects as part of the network creation process.

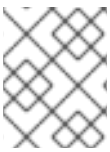
RHOSP provider networks map directly to an existing physical network in the data center. A RHOSP administrator must create them.

In the following example, OpenShift Container Platform workloads are connected to a data center by using a provider network:



OpenShift Container Platform clusters that are installed on provider networks do not require tenant networks or floating IP addresses. The installer does not create these resources during installation.

Example provider network types include flat (untagged) and VLAN (802.1Q tagged).



NOTE

A cluster can support as many provider network connections as the network type allows. For example, VLAN networks typically support up to 4096 connections.

You can learn more about provider and tenant networks in the RHOSP documentation.

19.5.13.10.1. RHOSP provider network requirements for cluster installation

Before you install an OpenShift Container Platform cluster, your Red Hat OpenStack Platform (RHOSP) deployment and provider network must meet a number of conditions:

- The RHOSP networking service (Neutron) is enabled and accessible through the RHOSP networking API.
- The RHOSP networking service has the port security and allowed address pairs extensions enabled.

- The provider network can be shared with other tenants.

  TIP

  Use the **openstack network create** command with the **--share** flag to create a network that can be shared.

- The RHOSP project that you use to install the cluster must own the provider network, as well as an appropriate subnet.

  TIP

  To create a network for a project that is named "openshift," enter the following command

  ```
  $ openstack network create --project openshift
  ```

  To create a subnet for a project that is named "openshift," enter the following command

  ```
  $ openstack subnet create --project openshift
  ```

  To learn more about creating networks on RHOSP, read the provider networks documentation.

  If the cluster is owned by the **admin** user, you must run the installer as that user to create ports on the network.

  IMPORTANT

  Provider networks must be owned by the RHOSP project that is used to create the cluster. If they are not, the RHOSP Compute service (Nova) cannot request a port from that network.

- Verify that the provider network can reach the RHOSP metadata service IP address, which is **169.254.169.254** by default.
  Depending on your RHOSP SDN and networking service configuration, you might need to provide the route when you create the subnet. For example:

  ```
  $ openstack subnet create --dhcp --host-route
  destination=169.254.169.254/32,gateway=192.0.2.2 ...
  ```

- Optional: To secure the network, create role-based access control (RBAC) rules that limit network access to a single project.

19.5.13.10.2. Deploying a cluster that has a primary interface on a provider network

You can deploy an OpenShift Container Platform cluster that has its primary network interface on an Red Hat OpenStack Platform (RHOSP) provider network.

Prerequisites

- Your Red Hat OpenStack Platform (RHOSP) deployment is configured as described by "RHOSP provider network requirements for cluster installation".

Procedure

1. In a text editor, open the **install-config.yaml** file.
2. Set the value of the **platform.openstack.apiVIP** property to the IP address for the API VIP.
3. Set the value of the **platform.openstack.ingressVIP** property to the IP address for the Ingress VIP.
4. Set the value of the **platform.openstack.machinesSubnet** property to the UUID of the provider network subnet.
5. Set the value of the **networking.machineNetwork.cidr** property to the CIDR block of the provider network subnet.

IMPORTANT

The **platform.openstack.apiVIP** and **platform.openstack.ingressVIP** properties must both be unassigned IP addresses from the **networking.machineNetwork.cidr** block.

Section of an installation configuration file for a cluster that relies on a RHOSP provider network

```
...
platform:
  openstack:
    apiVIP: 192.0.2.13
    ingressVIP: 192.0.2.23
    machinesSubnet: fa806b2f-ac49-4bce-b9db-124bc64209bf
    # ...
networking:
  machineNetwork:
  - cidr: 192.0.2.0/24
```

WARNING

You cannot set the **platform.openstack.externalNetwork** or **platform.openstack.externalDNS** parameters while using a provider network for the primary network interface.

When you deploy the cluster, the installer uses the **install-config.yaml** file to deploy the cluster on the provider network.

TIP

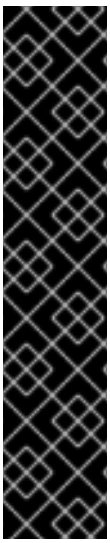
You can add additional networks, including provider networks, to the **platform.openstack.additionalNetworkIDs** list.

After you deploy your cluster, you can attach pods to additional networks. For more information, see Understanding multiple networks.

19.5.14. Creating the Kubernetes manifest and Ignition config files

Because you must modify some cluster definition files and manually start the cluster machines, you must generate the Kubernetes manifest and Ignition config files that the cluster needs to configure the machines.

The installation configuration file transforms into the Kubernetes manifests. The manifests wrap into the Ignition configuration files, which are later used to configure the cluster machines.



IMPORTANT

- The Ignition config files that the OpenShift Container Platform installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

Prerequisites

- You obtained the OpenShift Container Platform installation program.
- You created the **install-config.yaml** installation configuration file.

Procedure

1. Change to the directory that contains the OpenShift Container Platform installation program and generate the Kubernetes manifests for the cluster:

```
$ ./openshift-install create manifests --dir <installation_directory> 1
```

1 For **<installation_directory>**, specify the installation directory that contains the **install-config.yaml** file you created.

2. Remove the Kubernetes manifest files that define the control plane machines and compute machine sets:

```
$ rm -f openshift/99_openshift-cluster-api_master-machines-*.yaml openshift/99_openshift-cluster-api_worker-machineset-*.yaml
```

Because you create and manage these resources yourself, you do not have to initialize them.

- You can preserve the machine set files to create compute machines by using the machine API, but you must update references to them to match your environment.

3. Check that the **mastersSchedulable** parameter in the **<installation_directory>/manifests/cluster-scheduler-02-config.yml** Kubernetes manifest file is set to **false**. This setting prevents pods from being scheduled on the control plane machines:

   a. Open the **<installation_directory>/manifests/cluster-scheduler-02-config.yml** file.

   b. Locate the **mastersSchedulable** parameter and ensure that it is set to **false**.

   c. Save and exit the file.

4. To create the Ignition configuration files, run the following command from the directory that contains the installation program:

```
$ ./openshift-install create ignition-configs --dir <installation_directory> 1
```

1 For **<installation_directory>**, specify the same installation directory.

Ignition config files are created for the bootstrap, control plane, and compute nodes in the installation directory. The **kubeadmin-password** and **kubeconfig** files are created in the **./<installation_directory>/auth** directory:

```
.
├── auth
│   ├── kubeadmin-password
│   └── kubeconfig
├── bootstrap.ign
├── master.ign
├── metadata.json
└── worker.ign
```

5. Export the metadata file's **infraID** key as an environment variable:

```
$ export INFRA_ID=$(jq -r .infraID metadata.json)
```

TIP

Extract the **infraID** key from **metadata.json** and use it as a prefix for all of the RHOSP resources that you create. By doing so, you avoid name conflicts when making multiple deployments in the same project.

19.5.15. Preparing the bootstrap Ignition files

The OpenShift Container Platform installation process relies on bootstrap machines that are created from a bootstrap Ignition configuration file.

Edit the file and upload it. Then, create a secondary bootstrap Ignition configuration file that Red Hat OpenStack Platform (RHOSP) uses to download the primary file.

Prerequisites

- You have the bootstrap Ignition file that the installer program generates, **bootstrap.ign**.
- The infrastructure ID from the installer's metadata file is set as an environment variable (**$INFRA_ID**).
  - If the variable is not set, see **Creating the Kubernetes manifest and Ignition config files**
- You have an HTTP(S)-accessible way to store the bootstrap Ignition file.
  - The documented procedure uses the RHOSP image service (Glance), but you can also use the RHOSP storage service (Swift), Amazon S3, an internal HTTP server, or an ad hoc Nova server.

Procedure

1. Run the following Python script. The script modifies the bootstrap Ignition file to set the hostname and, if available, CA certificate file when it runs:

```
import base64
import json
import os

with open('bootstrap.ign', 'r') as f:
    ignition = json.load(f)

files = ignition['storage'].get('files', [])

infra_id = os.environ.get('INFRA_ID', 'openshift').encode()
hostname_b64 = base64.standard_b64encode(infra_id + b'-bootstrap\n').decode().strip()
files.append(
{
    'path': '/etc/hostname',
    'mode': 420,
    'contents': {
        'source': 'data:text/plain;charset=utf-8;base64,' + hostname_b64
    }
})

ca_cert_path = os.environ.get('OS_CACERT', '')
if ca_cert_path:
    with open(ca_cert_path, 'r') as f:
        ca_cert = f.read().encode()
        ca_cert_b64 = base64.standard_b64encode(ca_cert).decode().strip()

    files.append(
    {
        'path': '/opt/openshift/tls/cloud-ca-cert.pem',
        'mode': 420,
        'contents': {
            'source': 'data:text/plain;charset=utf-8;base64,' + ca_cert_b64
        }
    })

ignition['storage']['files'] = files;
```

```
with open('bootstrap.ign', 'w') as f:
    json.dump(ignition, f)
```

2. Using the RHOSP CLI, create an image that uses the bootstrap Ignition file:

```
$ openstack image create --disk-format=raw --container-format=bare --file bootstrap.ign
<image_name>
```

3. Get the image's details:

```
$ openstack image show <image_name>
```

Make a note of the **file** value; it follows the pattern **v2/images/<image_ID>/file**.

NOTE

Verify that the image you created is active.

4. Retrieve the image service's public address:

```
$ openstack catalog show image
```

5. Combine the public address with the image **file** value and save the result as the storage location. The location follows the pattern **<image_service_public_URL>/v2/images/<image_ID>/file**.

6. Generate an auth token and save the token ID:

```
$ openstack token issue -c id -f value
```

7. Insert the following content into a file called **$INFRA_ID-bootstrap-ignition.json** and edit the placeholders to match your own values:

```
{
  "ignition": {
    "config": {
      "merge": [{
        "source": "<storage_url>", 1
        "httpHeaders": [{
          "name": "X-Auth-Token", 2
          "value": "<token_ID>" 3
        }]
      }]
    },
    "security": {
      "tls": {
        "certificateAuthorities": [{
          "source": "data:text/plain;charset=utf-8;base64,<base64_encoded_certificate>" 4
        }]
      }
    },
```

```
    "version": "3.2.0"
  }
}
```

1. Replace the value of **ignition.config.merge.source** with the bootstrap Ignition file storage URL.
2. Set **name** in **httpHeaders** to **"X-Auth-Token"**.
3. Set **value** in **httpHeaders** to your token's ID.
4. If the bootstrap Ignition file server uses a self-signed certificate, include the base64-encoded certificate.

8. Save the secondary Ignition config file.

The bootstrap Ignition data will be passed to RHOSP during installation.

WARNING

The bootstrap Ignition file contains sensitive information, like **clouds.yaml** credentials. Ensure that you store it in a secure place, and delete it after you complete the installation process.

19.5.16. Creating control plane Ignition config files on RHOSP

Installing OpenShift Container Platform on Red Hat OpenStack Platform (RHOSP) on your own infrastructure requires control plane Ignition config files. You must create multiple config files.

NOTE

As with the bootstrap Ignition configuration, you must explicitly define a hostname for each control plane machine.

Prerequisites

- The infrastructure ID from the installation program's metadata file is set as an environment variable (**$INFRA_ID**).
  - If the variable is not set, see "Creating the Kubernetes manifest and Ignition config files".

Procedure

- On a command line, run the following Python script:

```
$ for index in $(seq 0 2); do
    MASTER_HOSTNAME="$INFRA_ID-master-$index\n"
    python -c "import base64, json, sys;
ignition = json.load(sys.stdin);
storage = ignition.get('storage', {});
```

```
files = storage.get('files', []);
files.append({'path': '/etc/hostname', 'mode': 420, 'contents': {'source':
'data:text/plain;charset=utf-8;base64,' +
base64.standard_b64encode(b'$MASTER_HOSTNAME').decode().strip(), 'verification': {}},
'filesystem': 'root'});
storage['files'] = files;
ignition['storage'] = storage
json.dump(ignition, sys.stdout)" <master.ign >"$INFRA_ID-master-$index-ignition.json"
done
```

You now have three control plane Ignition files: **<INFRA_ID>-master-0-ignition.json**, **<INFRA_ID>-master-1-ignition.json**, and **<INFRA_ID>-master-2-ignition.json**.

19.5.17. Creating network resources on RHOSP

Create the network resources that an OpenShift Container Platform on Red Hat OpenStack Platform (RHOSP) installation on your own infrastructure requires. To save time, run supplied Ansible playbooks that generate security groups, networks, subnets, routers, and ports.

Prerequisites

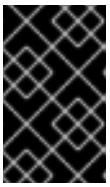
- Python 3 is installed on your machine.
- You downloaded the modules in "Downloading playbook dependencies".
- You downloaded the playbooks in "Downloading the installation playbooks".

Procedure

1. Optional: Add an external network value to the **inventory.yaml** playbook:

   Example external network value in the inventory.yaml Ansible playbook

```
...
    # The public network providing connectivity to the cluster. If not
    # provided, the cluster external connectivity must be provided in another
    # way.

    # Required for os_api_fip, os_ingress_fip, os_bootstrap_fip.
    os_external_network: 'external'
...
```



IMPORTANT

If you did not provide a value for **os_external_network** in the **inventory.yaml** file, you must ensure that VMs can access Glance and an external connection yourself.

2. Optional: Add external network and floating IP (FIP) address values to the **inventory.yaml** playbook:

   Example FIP values in the inventory.yaml Ansible playbook

```
...
```

```
# OpenShift API floating IP address. If this value is non-empty, the
# corresponding floating IP will be attached to the Control Plane to
# serve the OpenShift API.
os_api_fip: '203.0.113.23'

# OpenShift Ingress floating IP address. If this value is non-empty, the
# corresponding floating IP will be attached to the worker nodes to serve
# the applications.
os_ingress_fip: '203.0.113.19'

# If this value is non-empty, the corresponding floating IP will be
# attached to the bootstrap machine. This is needed for collecting logs
# in case of install failure.
os_bootstrap_fip: '203.0.113.20'
```

IMPORTANT

If you do not define values for **os_api_fip** and **os_ingress_fip**, you must perform postinstallation network configuration.

If you do not define a value for **os_bootstrap_fip**, the installer cannot download debugging information from failed installations.

See "Enabling access to the environment" for more information.

3. On a command line, create security groups by running the **security-groups.yaml** playbook:

```
$ ansible-playbook -i inventory.yaml security-groups.yaml
```

4. On a command line, create a network, subnet, and router by running the **network.yaml** playbook:

```
$ ansible-playbook -i inventory.yaml network.yaml
```

5. Optional: If you want to control the default resolvers that Nova servers use, run the RHOSP CLI command:

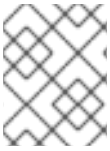
```
$ openstack subnet set --dns-nameserver <server_1> --dns-nameserver <server_2>
"$INFRA_ID-nodes"
```

Optionally, you can use the **inventory.yaml** file that you created to customize your installation. For example, you can deploy a cluster that uses bare metal machines.

19.5.17.1. Deploying a cluster with bare metal machines

If you want your cluster to use bare metal machines, modify the **inventory.yaml** file. Your cluster can have both control plane and compute machines running on bare metal, or just compute machines.

Bare-metal compute machines are not supported on clusters that use Kuryr.



NOTE

Be sure that your **install-config.yaml** file reflects whether the RHOSP network that you use for bare metal workers supports floating IP addresses or not.

Prerequisites

- The RHOSP Bare Metal service (Ironic) is enabled and accessible via the RHOSP Compute API.
- Bare metal is available as a RHOSP flavor.
- If your cluster runs on an RHOSP version that is more than 16.1.6 and less than 16.2.4, bare metal workers do not function due to a known issue that causes the metadata service to be unavailable for services on OpenShift Container Platform nodes.
- The RHOSP network supports both VM and bare metal server attachment.
- Your network configuration does not rely on a provider network. Provider networks are not supported.
- If you want to deploy the machines on a pre-existing network, a RHOSP subnet is provisioned.
- If you want to deploy the machines on an installer-provisioned network, the RHOSP Bare Metal service (Ironic) is able to listen for and interact with Preboot eXecution Environment (PXE) boot machines that run on tenant networks.
- You created an **inventory.yaml** file as part of the OpenShift Container Platform installation process.

Procedure

1. In the **inventory.yaml** file, edit the flavors for machines:
   a. If you want to use bare-metal control plane machines, change the value of **os_flavor_master** to a bare metal flavor.
   b. Change the value of **os_flavor_worker** to a bare metal flavor.

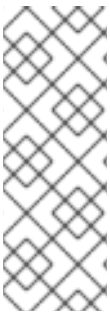
An example bare metal inventory.yaml file

```
all:
  hosts:
    localhost:
      ansible_connection: local
      ansible_python_interpreter: "{{ansible_playbook_python}}"

      # User-provided values
      os_subnet_range: '10.0.0.0/16'
      os_flavor_master: 'my-bare-metal-flavor' 1
      os_flavor_worker: 'my-bare-metal-flavor' 2
      os_image_rhcos: 'rhcos'
      os_external_network: 'external'
...
```

1 If you want to have bare-metal control plane machines, change this value to a bare metal flavor.

2 Change this value to a bare metal flavor to use for compute machines.

Use the updated **inventory.yaml** file to complete the installation process. Machines that are created during deployment use the flavor that you added to the file.



NOTE

The installer may time out while waiting for bare metal machines to boot.

If the installer times out, restart and then complete the deployment by using the **wait-for** command of the installer. For example:

```
$ ./openshift-install wait-for install-complete --log-level debug
```

19.5.18. Creating the bootstrap machine on RHOSP

Create a bootstrap machine and give it the network access it needs to run on Red Hat OpenStack Platform (RHOSP). Red Hat provides an Ansible playbook that you run to simplify this process.

Prerequisites

- You downloaded the modules in "Downloading playbook dependencies".
- You downloaded the playbooks in "Downloading the installation playbooks".
- The **inventory.yaml**, **common.yaml**, and **bootstrap.yaml** Ansible playbooks are in a common directory.
- The **metadata.json** file that the installation program created is in the same directory as the Ansible playbooks.

Procedure

1. On a command line, change the working directory to the location of the playbooks.
2. On a command line, run the **bootstrap.yaml** playbook:

```
$ ansible-playbook -i inventory.yaml bootstrap.yaml
```

3. After the bootstrap server is active, view the logs to verify that the Ignition files were received:

```
$ openstack console log show "$INFRA_ID-bootstrap"
```

19.5.19. Creating the control plane machines on RHOSP

Create three control plane machines by using the Ignition config files that you generated. Red Hat provides an Ansible playbook that you run to simplify this process.

Prerequisites

- You downloaded the modules in "Downloading playbook dependencies".

- You downloaded the playbooks in "Downloading the installation playbooks".
- The infrastructure ID from the installation program's metadata file is set as an environment variable (**$INFRA_ID**).
- The **inventory.yaml**, **common.yaml**, and **control-plane.yaml** Ansible playbooks are in a common directory.
- You have the three Ignition files that were created in "Creating control plane Ignition config files".

Procedure

1. On a command line, change the working directory to the location of the playbooks.
2. If the control plane Ignition config files aren't already in your working directory, copy them into it.
3. On a command line, run the **control-plane.yaml** playbook:

```
$ ansible-playbook -i inventory.yaml control-plane.yaml
```

4. Run the following command to monitor the bootstrapping process:

```
$ openshift-install wait-for bootstrap-complete
```

You will see messages that confirm that the control plane machines are running and have joined the cluster:

```
INFO API v1.24.0 up
INFO Waiting up to 30m0s for bootstrapping to complete...
...
INFO It is now safe to remove the bootstrap resources
```

19.5.20. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

Example output

```
system:admin
```

19.5.21. Deleting bootstrap resources from RHOSP

Delete the bootstrap resources that you no longer need.

Prerequisites

- You downloaded the modules in "Downloading playbook dependencies".
- You downloaded the playbooks in "Downloading the installation playbooks".
- The **inventory.yaml**, **common.yaml**, and **down-bootstrap.yaml** Ansible playbooks are in a common directory.
- The control plane machines are running.
  - If you do not know the status of the machines, see "Verifying cluster status".

Procedure

1. On a command line, change the working directory to the location of the playbooks.
2. On a command line, run the **down-bootstrap.yaml** playbook:

```
$ ansible-playbook -i inventory.yaml down-bootstrap.yaml
```

The bootstrap port, server, and floating IP address are deleted.

WARNING

If you did not disable the bootstrap Ignition file URL earlier, do so now.

19.5.22. Creating compute machines on RHOSP

After standing up the control plane, create compute machines. Red Hat provides an Ansible playbook that you run to simplify this process.

Prerequisites

- You downloaded the modules in "Downloading playbook dependencies".
- You downloaded the playbooks in "Downloading the installation playbooks".
- The **inventory.yaml**, **common.yaml**, and **compute-nodes.yaml** Ansible playbooks are in a common directory.
- The **metadata.json** file that the installation program created is in the same directory as the Ansible playbooks.
- The control plane is active.

Procedure

1. On a command line, change the working directory to the location of the playbooks.
2. On a command line, run the playbook:

```
$ ansible-playbook -i inventory.yaml compute-nodes.yaml
```

Next steps

- Approve the certificate signing requests for the machines.

19.5.23. Approving the certificate signing requests for your machines

When you add machines to a cluster, two pending certificate signing requests (CSRs) are generated for each machine that you added. You must confirm that these CSRs are approved or, if necessary, approve them yourself. The client requests must be approved first, followed by the server requests.

Prerequisites

- You added machines to your cluster.

Procedure

1. Confirm that the cluster recognizes the machines:

```
$ oc get nodes
```

Example output

```
NAME      STATUS    ROLES   AGE  VERSION
master-0  Ready     master  63m  v1.24.0
master-1  Ready     master  63m  v1.24.0
master-2  Ready     master  64m  v1.24.0
```

The output lists all of the machines that you created.

NOTE

The preceding output might not include the compute nodes, also known as worker nodes, until some CSRs are approved.

2. Review the pending CSRs and ensure that you see the client requests with the **Pending** or **Approved** status for each machine that you added to the cluster:

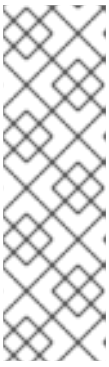
```
$ oc get csr
```

Example output

```
NAME        AGE    REQUESTOR                                                   CONDITION
csr-8b2br   15m    system:serviceaccount:openshift-machine-config-operator:node-bootstrapper   Pending
csr-8vnps   15m    system:serviceaccount:openshift-machine-config-operator:node-bootstrapper   Pending
...
```

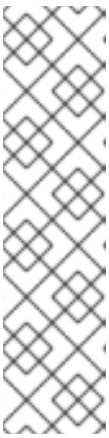
In this example, two machines are joining the cluster. You might see more approved CSRs in the list.

3. If the CSRs were not approved, after all of the pending CSRs for the machines you added are in **Pending** status, approve the CSRs for your cluster machines:



NOTE

Because the CSRs rotate automatically, approve your CSRs within an hour of adding the machines to the cluster. If you do not approve them within an hour, the certificates will rotate, and more than two certificates will be present for each node. You must approve all of these certificates. After the client CSR is approved, the Kubelet creates a secondary CSR for the serving certificate, which requires manual approval. Then, subsequent serving certificate renewal requests are automatically approved by the **machine-approver** if the Kubelet requests a new certificate with identical parameters.



NOTE

For clusters running on platforms that are not machine API enabled, such as bare metal and other user-provisioned infrastructure, you must implement a method of automatically approving the kubelet serving certificate requests (CSRs). If a request is not approved, then the **oc exec**, **oc rsh**, and **oc logs** commands cannot succeed, because a serving certificate is required when the API server connects to the kubelet. Any operation that contacts the Kubelet endpoint requires this certificate approval to be in place. The method must watch for new CSRs, confirm that the CSR was submitted by the **node-bootstrapper** service account in the **system:node** or **system:admin** groups, and confirm the identity of the node.

- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

1 **<csr_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{{"\n"}}
{{end}}{{end}}' | xargs --no-run-if-empty oc adm certificate approve
```

NOTE

Some Operators might not become available until some CSRs are approved.

4. Now that your client requests are approved, you must review the server requests for each machine that you added to the cluster:

```
$ oc get csr
```

Example output

```
NAME        AGE     REQUESTOR                                                   CONDITION
csr-bfd72   5m26s   system:node:ip-10-0-50-126.us-east-2.compute.internal
Pending
csr-c57lv   5m26s   system:node:ip-10-0-95-157.us-east-2.compute.internal
Pending
...
```

5. If the remaining CSRs are not approved, and are in the **Pending** status, approve the CSRs for your cluster machines:

- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

1 **<csr_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{{"\n"}}
{{end}}{{end}}' | xargs oc adm certificate approve
```

6. After all client and server CSRs have been approved, the machines have the **Ready** status. Verify this by running the following command:

```
$ oc get nodes
```

Example output

```
NAME      STATUS    ROLES   AGE  VERSION
master-0  Ready     master  73m  v1.24.0
master-1  Ready     master  73m  v1.24.0
master-2  Ready     master  74m  v1.24.0
worker-0  Ready     worker  11m  v1.24.0
worker-1  Ready     worker  11m  v1.24.0
```

NOTE

It can take a few minutes after approval of the server CSRs for the machines to transition to the **Ready** status.

Additional information

- For more information on CSRs, see Certificate Signing Requests .

19.5.24. Verifying a successful installation

Verify that the OpenShift Container Platform installation is complete.

Prerequisites

- You have the installation program (**openshift-install**)

Procedure

- On a command line, enter:

```
$ openshift-install --log-level debug wait-for install-complete
```

The program outputs the console URL, as well as the administrator's login information.

19.5.25. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.11, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to OpenShift Cluster Manager Hybrid Cloud Console.

After you confirm that your OpenShift Cluster Manager Hybrid Cloud Console inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, use subscription watch to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

Additional resources

- See About remote health monitoring for more information about the Telemetry service

19.5.26. Next steps

- Customize your cluster.
- If necessary, you can opt out of remote health reporting .
- If you need to enable external access to node ports, configure ingress cluster traffic by using a node port.
- If you did not configure RHOSP to accept application traffic over floating IP addresses, configure RHOSP access with floating IP addresses .

19.6. INSTALLING A CLUSTER ON OPENSTACK WITH KURYR ON YOUR OWN INFRASTRUCTURE

In OpenShift Container Platform version 4.11, you can install a cluster on Red Hat OpenStack Platform (RHOSP) that runs on user-provisioned infrastructure.

Using your own infrastructure allows you to integrate your cluster with existing infrastructure and modifications. The process requires more labor on your part than installer-provisioned installations, because you must create all RHOSP resources, like Nova servers, Neutron ports, and security groups. However, Red Hat provides Ansible playbooks to help you in the deployment process.

19.6.1. Prerequisites

- You reviewed details about the OpenShift Container Platform installation and update processes.
- You read the documentation on selecting a cluster installation method and preparing it for users.
- You verified that OpenShift Container Platform 4.11 is compatible with your RHOSP version by using the Supported platforms for OpenShift clusters section. You can also compare platform support across different versions by viewing the OpenShift Container Platform on RHOSP support matrix.
- You have an RHOSP account where you want to install OpenShift Container Platform.
- You understand performance and scalability practices for cluster scaling, control plane sizing, and etcd. For more information, see Recommended host practices.
- On the machine from which you run the installation program, you have:
  - A single directory in which you can keep the files you create during the installation process
  - Python 3

19.6.2. About Kuryr SDN

Kuryr is a container network interface (CNI) plugin solution that uses the Neutron and Octavia Red Hat OpenStack Platform (RHOSP) services to provide networking for pods and Services.

Kuryr and OpenShift Container Platform integration is primarily designed for OpenShift Container Platform clusters running on RHOSP VMs. Kuryr improves the network performance by plugging OpenShift Container Platform pods into RHOSP SDN. In addition, it provides interconnectivity between pods and RHOSP virtual instances.

Kuryr components are installed as pods in OpenShift Container Platform using the **openshift-kuryr** namespace:

- **kuryr-controller** - a single service instance installed on a **master** node. This is modeled in OpenShift Container Platform as a **Deployment** object.
- **kuryr-cni** - a container installing and configuring Kuryr as a CNI driver on each OpenShift Container Platform node. This is modeled in OpenShift Container Platform as a **DaemonSet** object.

The Kuryr controller watches the OpenShift Container Platform API server for pod, service, and

namespace create, update, and delete events. It maps the OpenShift Container Platform API calls to corresponding objects in Neutron and Octavia. This means that every network solution that implements the Neutron trunk port functionality can be used to back OpenShift Container Platform via Kuryr. This includes open source solutions such as Open vSwitch (OVS) and Open Virtual Network (OVN) as well as Neutron-compatible commercial SDNs.

Kuryr is recommended for OpenShift Container Platform deployments on encapsulated RHOSP tenant networks to avoid double encapsulation, such as running an encapsulated OpenShift Container Platform SDN over an RHOSP network.

If you use provider networks or tenant VLANs, you do not need to use Kuryr to avoid double encapsulation. The performance benefit is negligible. Depending on your configuration, though, using Kuryr to avoid having two overlays might still be beneficial.

Kuryr is not recommended in deployments where all of the following criteria are true:

- The RHOSP version is less than 16.
- The deployment uses UDP services, or a large number of TCP services on few hypervisors.

or

- The **ovn-octavia** Octavia driver is disabled.
- The deployment uses a large number of TCP services on few hypervisors.

19.6.3. Resource guidelines for installing OpenShift Container Platform on RHOSP with Kuryr

When using Kuryr SDN, the pods, services, namespaces, and network policies are using resources from the RHOSP quota; this increases the minimum requirements. Kuryr also has some additional requirements on top of what a default install requires.

Use the following quota to satisfy a default cluster's minimum requirements:

Table 19.19. Recommended resources for a default OpenShift Container Platform cluster on RHOSP with Kuryr

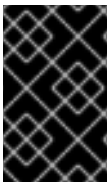
Resource	Value
Floating IP addresses	3 - plus the expected number of Services of LoadBalancer type
Ports	1500 - 1 needed per Pod
Routers	1
Subnets	250 - 1 needed per Namespace/Project
Networks	250 - 1 needed per Namespace/Project
RAM	112 GB

Resource	Value
vCPUs	28
Volume storage	275 GB
Instances	7
Security groups	250 - 1 needed per Service and per NetworkPolicy
Security group rules	1000
Server groups	2 - plus 1 for each additional availability zone in each machine pool
Load balancers	100 - 1 needed per Service
Load balancer listeners	500 - 1 needed per Service-exposed port
Load balancer pools	500 - 1 needed per Service-exposed port

A cluster might function with fewer than recommended resources, but its performance is not guaranteed.

IMPORTANT

If RHOSP object storage (Swift) is available and operated by a user account with the **swiftoperator** role, it is used as the default backend for the OpenShift Container Platform image registry. In this case, the volume storage requirement is 175 GB. Swift space requirements vary depending on the size of the image registry.



IMPORTANT

If you are using Red Hat OpenStack Platform (RHOSP) version 16 with the Amphora driver rather than the OVN Octavia driver, security groups are associated with service accounts instead of user projects.

Take the following notes into consideration when setting resources:

- The number of ports that are required is larger than the number of pods. Kuryr uses ports pools to have pre-created ports ready to be used by pods and speed up the pods' booting time.
- Each network policy is mapped into an RHOSP security group, and depending on the **NetworkPolicy** spec, one or more rules are added to the security group.
- Each service is mapped to an RHOSP load balancer. Consider this requirement when estimating the number of security groups required for the quota.
  If you are using RHOSP version 15 or earlier, or the **ovn-octavia driver**, each load balancer has a security group with the user project.

- The quota does not account for load balancer resources (such as VM resources), but you must consider these resources when you decide the RHOSP deployment's size. The default installation will have more than 50 load balancers; the clusters must be able to accommodate them.
  If you are using RHOSP version 16 with the OVN Octavia driver enabled, only one load balancer VM is generated; services are load balanced through OVN flows.

An OpenShift Container Platform deployment comprises control plane machines, compute machines, and a bootstrap machine.

To enable Kuryr SDN, your environment must meet the following requirements:

- Run RHOSP 13+.
- Have Overcloud with Octavia.
- Use Neutron Trunk ports extension.
- Use **openvswitch** firewall driver if ML2/OVS Neutron driver is used instead of **ovs-hybrid**.

19.6.3.1. Increasing quota

When using Kuryr SDN, you must increase quotas to satisfy the Red Hat OpenStack Platform (RHOSP) resources used by pods, services, namespaces, and network policies.

Procedure

- Increase the quotas for a project by running the following command:

```
$ sudo openstack quota set --secgroups 250 --secgroup-rules 1000 --ports 1500 --subnets
250 --networks 250 <project>
```

19.6.3.2. Configuring Neutron

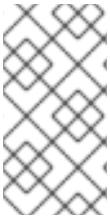
Kuryr CNI leverages the Neutron Trunks extension to plug containers into the Red Hat OpenStack Platform (RHOSP) SDN, so you must use the **trunks** extension for Kuryr to properly work.

In addition, if you leverage the default ML2/OVS Neutron driver, the firewall must be set to **openvswitch** instead of **ovs_hybrid** so that security groups are enforced on trunk subports and Kuryr can properly handle network policies.

19.6.3.3. Configuring Octavia

Kuryr SDN uses Red Hat OpenStack Platform (RHOSP)'s Octavia LBaaS to implement OpenShift Container Platform services. Thus, you must install and configure Octavia components in RHOSP to use Kuryr SDN.

To enable Octavia, you must include the Octavia service during the installation of the RHOSP Overcloud, or upgrade the Octavia service if the Overcloud already exists. The following steps for enabling Octavia apply to both a clean install of the Overcloud or an Overcloud update.



NOTE

The following steps only capture the key pieces required during the deployment of RHOSP when dealing with Octavia. It is also important to note that registry methods vary.

This example uses the local registry method.

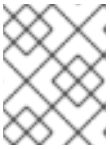
Procedure

1. If you are using the local registry, create a template to upload the images to the registry. For example:

```
(undercloud) $ openstack overcloud container image prepare \
-e /usr/share/openstack-tripleo-heat-templates/environments/services-docker/octavia.yaml \
--namespace=registry.access.redhat.com/rhosp13 \
--push-destination=<local-ip-from-undercloud.conf>:8787 \
--prefix=openstack- \
--tag-from-label {version}-{product-version} \
--output-env-file=/home/stack/templates/overcloud_images.yaml \
--output-images-file /home/stack/local_registry_images.yaml
```

2. Verify that the **local_registry_images.yaml** file contains the Octavia images. For example:

```
...
- imagename: registry.access.redhat.com/rhosp13/openstack-octavia-api:13.0-43
  push_destination: <local-ip-from-undercloud.conf>:8787
- imagename: registry.access.redhat.com/rhosp13/openstack-octavia-health-manager:13.0-
45
  push_destination: <local-ip-from-undercloud.conf>:8787
- imagename: registry.access.redhat.com/rhosp13/openstack-octavia-housekeeping:13.0-45
  push_destination: <local-ip-from-undercloud.conf>:8787
- imagename: registry.access.redhat.com/rhosp13/openstack-octavia-worker:13.0-44
  push_destination: <local-ip-from-undercloud.conf>:8787
```



NOTE

The Octavia container versions vary depending upon the specific RHOSP release installed.

3. Pull the container images from **registry.redhat.io** to the Undercloud node:

```
(undercloud) $ sudo openstack overcloud container image upload \
  --config-file  /home/stack/local_registry_images.yaml \
  --verbose
```

This may take some time depending on the speed of your network and Undercloud disk.

4. Since an Octavia load balancer is used to access the OpenShift Container Platform API, you must increase their listeners' default timeouts for the connections. The default timeout is 50 seconds. Increase the timeout to 20 minutes by passing the following file to the Overcloud deploy command:

```
(undercloud) $ cat octavia_timeouts.yaml
parameter_defaults:
```

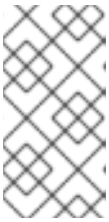
```
OctaviaTimeoutClientData: 1200000
OctaviaTimeoutMemberData: 1200000
```

NOTE

This is not needed for RHOSP 13.0.13+.

5. Install or update your Overcloud environment with Octavia:

```
$ openstack overcloud deploy --templates \
  -e /usr/share/openstack-tripleo-heat-templates/environments/services-docker/octavia.yaml \
  -e octavia_timeouts.yaml
```



NOTE

This command only includes the files associated with Octavia; it varies based on your specific installation of RHOSP. See the RHOSP documentation for further information. For more information on customizing your Octavia installation, see installation of Octavia using Director.

NOTE

When leveraging Kuryr SDN, the Overcloud installation requires the Neutron **trunk** extension. This is available by default on director deployments. Use the **openvswitch** firewall instead of the default **ovs-hybrid** when the Neutron backend is ML2/OVS. There is no need for modifications if the backend is ML2/OVN.

6. In RHOSP versions earlier than 13.0.13, add the project ID to the **octavia.conf** configuration file after you create the project.

- To enforce network policies across services, like when traffic goes through the Octavia load balancer, you must ensure Octavia creates the Amphora VM security groups on the user project.
  This change ensures that required load balancer security groups belong to that project, and that they can be updated to enforce services isolation.

NOTE

This task is unnecessary in RHOSP version 13.0.13 or later.

Octavia implements a new ACL API that restricts access to the load balancers VIP.

a. Get the project ID

```
$ openstack project show <project>
```

Example output

```
+-------------+----------------------------------+
| Field       | Value                            |
```

```
+-------------+----------------------------------+
| description |                                  |
| domain_id   | default                          |
| enabled     | True                             |
| id          | PROJECT_ID                       |
| is_domain   | False                            |
| name        | *<project>*                      |
| parent_id   | default                          |
| tags        | []                               |
+-------------+----------------------------------+
```

b. Add the project ID to **octavia.conf** for the controllers.

i. Source the **stackrc** file:

```
$ source stackrc  # Undercloud credentials
```

ii. List the Overcloud controllers:

```
$ openstack server list
```

Example output

```
+--------------------------------------+-------------+--------+----------------------+-------
---------+------------+
|
| ID                                   | Name        | Status | Networks
| Image          | Flavor     |
|
+--------------------------------------+-------------+--------+----------------------+-------
---------+------------+
|
| 6bef8e73-2ba5-4860-a0b1-3937f8ca7e01 | controller-0 | ACTIVE |
ctlplane=192.168.24.8 | overcloud-full | controller |
|
| dda3173a-ab26-47f8-a2dc-8473b4a67ab9 | compute-0    | ACTIVE |
ctlplane=192.168.24.6 | overcloud-full | compute    |
|
+--------------------------------------+-------------+--------+----------------------+-------
---------+------------+
```

iii. SSH into the controller(s).

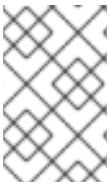
```
$ ssh heat-admin@192.168.24.8
```

iv. Edit the **octavia.conf** file to add the project into the list of projects where Amphora security groups are on the user's account.

```
# List of project IDs that are allowed to have Load balancer security groups
# belonging to them.
amp_secgroup_allowed_projects = PROJECT_ID
```

c. Restart the Octavia worker so the new configuration loads.

```
controller-0$ sudo docker restart octavia_worker
```



NOTE

Depending on your RHOSP environment, Octavia might not support UDP listeners. If you use Kuryr SDN on RHOSP version 13.0.13 or earlier, UDP services are not supported. RHOSP version 16 or later support UDP.

19.6.3.3.1. The Octavia OVN Driver

Octavia supports multiple provider drivers through the Octavia API.

To see all available Octavia provider drivers, on a command line, enter:

```
$ openstack loadbalancer provider list
```

Example output

```
+---------+-------------------------------------------------+
| name    | description                                     |
+---------+-------------------------------------------------+
| amphora | The Octavia Amphora driver.                     |
| octavia | Deprecated alias of the Octavia Amphora driver. |
| ovn     | Octavia OVN driver.                             |
+---------+-------------------------------------------------+
```

Beginning with RHOSP version 16, the Octavia OVN provider driver (**ovn**) is supported on OpenShift Container Platform on RHOSP deployments.

ovn is an integration driver for the load balancing that Octavia and OVN provide. It supports basic load balancing capabilities, and is based on OpenFlow rules. The driver is automatically enabled in Octavia by Director on deployments that use OVN Neutron ML2.

The Amphora provider driver is the default driver. If **ovn** is enabled, however, Kuryr uses it.

If Kuryr uses **ovn** instead of Amphora, it offers the following benefits:

- Decreased resource requirements. Kuryr does not require a load balancer VM for each service.
- Reduced network latency.
- Increased service creation speed by using OpenFlow rules instead of a VM for each service.
- Distributed load balancing actions across all nodes instead of centralized on Amphora VMs.

19.6.3.4. Known limitations of installing with Kuryr

Using OpenShift Container Platform with Kuryr SDN has several known limitations.

RHOSP general limitations
Using OpenShift Container Platform with Kuryr SDN has several limitations that apply to all versions and environments:

- **Service** objects with the **NodePort** type are not supported.

- Clusters that use the OVN Octavia provider driver support **Service** objects for which the **.spec.selector** property is unspecified only if the **.subsets.addresses** property of the **Endpoints** object includes the subnet of the nodes or pods.

- If the subnet on which machines are created is not connected to a router, or if the subnet is connected, but the router has no external gateway set, Kuryr cannot create floating IPs for **Service** objects with type **LoadBalancer**.

- Configuring the **sessionAffinity=ClientIP** property on **Service** objects does not have an effect. Kuryr does not support this setting.

RHOSP version limitations
Using OpenShift Container Platform with Kuryr SDN has several limitations that depend on the RHOSP version.

- RHOSP versions before 16 use the default Octavia load balancer driver (Amphora). This driver requires that one Amphora load balancer VM is deployed per OpenShift Container Platform service. Creating too many services can cause you to run out of resources.
  Deployments of later versions of RHOSP that have the OVN Octavia driver disabled also use the Amphora driver. They are subject to the same resource concerns as earlier versions of RHOSP.

- Octavia RHOSP versions before 13.0.13 do not support UDP listeners. Therefore, OpenShift Container Platform UDP services are not supported.

- Octavia RHOSP versions before 13.0.13 cannot listen to multiple protocols on the same port. Services that expose the same port to different protocols, like TCP and UDP, are not supported.

- Kuryr SDN does not support automatic unidling by a service.

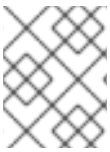
RHOSP environment limitations
There are limitations when using Kuryr SDN that depend on your deployment environment.

Because of Octavia's lack of support for the UDP protocol and multiple listeners, if the RHOSP version is earlier than 13.0.13, Kuryr forces pods to use TCP for DNS resolution.

In Go versions 1.12 and earlier, applications that are compiled with CGO support disabled use UDP only. In this case, the native Go resolver does not recognize the **use-vc** option in **resolv.conf**, which controls whether TCP is forced for DNS resolution. As a result, UDP is still used for DNS resolution, which fails.

To ensure that TCP forcing is allowed, compile applications either with the environment variable **CGO_ENABLED** set to **1**, i.e. **CGO_ENABLED=1**, or ensure that the variable is absent.

In Go versions 1.13 and later, TCP is used automatically if DNS resolution using UDP fails.



NOTE

musl-based containers, including Alpine-based containers, do not support the **use-vc** option.

RHOSP upgrade limitations
As a result of the RHOSP upgrade process, the Octavia API might be changed, and upgrades to the Amphora images that are used for load balancers might be required.

You can address API changes on an individual basis.

If the Amphora image is upgraded, the RHOSP operator can handle existing load balancer VMs in two ways:

- Upgrade each VM by triggering a load balancer failover.
- Leave responsibility for upgrading the VMs to users.

If the operator takes the first option, there might be short downtimes during failovers.

If the operator takes the second option, the existing load balancers will not support upgraded Octavia API features, like UDP listeners. In this case, users must recreate their Services to use these features.

IMPORTANT

If OpenShift Container Platform detects a new Octavia version that supports UDP load balancing, it recreates the DNS service automatically. The service recreation ensures that the service default supports UDP load balancing.

The recreation causes the DNS service approximately one minute of downtime.

19.6.3.5. Control plane machines

By default, the OpenShift Container Platform installation process creates three control plane machines.

Each machine requires:

- An instance from the RHOSP quota
- A port from the RHOSP quota
- A flavor with at least 16 GB memory and 4 vCPUs
- At least 100 GB storage space from the RHOSP quota

19.6.3.6. Compute machines

By default, the OpenShift Container Platform installation process creates three compute machines.

Each machine requires:

- An instance from the RHOSP quota
- A port from the RHOSP quota
- A flavor with at least 8 GB memory and 2 vCPUs
- At least 100 GB storage space from the RHOSP quota

TIP

Compute machines host the applications that you run on OpenShift Container Platform; aim to run as many as you can.

19.6.3.7. Bootstrap machine

During installation, a bootstrap machine is temporarily provisioned to stand up the control plane. After the production control plane is ready, the bootstrap machine is deprovisioned.

The bootstrap machine requires:

- An instance from the RHOSP quota
- A port from the RHOSP quota
- A flavor with at least 16 GB memory and 4 vCPUs
- At least 100 GB storage space from the RHOSP quota

19.6.4. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.11, you require access to the internet to install your cluster.

You must have internet access to:

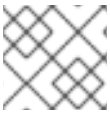
- Access OpenShift Cluster Manager Hybrid Cloud Console to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access Quay.io to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.

IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

19.6.5. Downloading playbook dependencies

The Ansible playbooks that simplify the installation process on user-provisioned infrastructure require several Python modules. On the machine where you will run the installer, add the modules' repositories and then download them.



NOTE

These instructions assume that you are using Red Hat Enterprise Linux (RHEL) 8.

Prerequisites

- Python 3 is installed on your machine.

Procedure

1. On a command line, add the repositories:
   a. Register with Red Hat Subscription Manager:
      -

```
$ sudo subscription-manager register # If not done already
```

b. Pull the latest subscription data:

```
$ sudo subscription-manager attach --pool=$YOUR_POOLID # If not done already
```

c. Disable the current repositories:

```
$ sudo subscription-manager repos --disable=* # If not done already
```

d. Add the required repositories:

```
$ sudo subscription-manager repos \
  --enable=rhel-8-for-x86_64-baseos-rpms \
  --enable=openstack-16-tools-for-rhel-8-x86_64-rpms \
  --enable=ansible-2.9-for-rhel-8-x86_64-rpms \
  --enable=rhel-8-for-x86_64-appstream-rpms
```

2. Install the modules:

```
$ sudo yum install python3-openstackclient ansible python3-openstacksdk python3-netaddr
```

3. Ensure that the **python** command points to **python3**:

```
$ sudo alternatives --set python /usr/bin/python3
```

19.6.6. Downloading the installation playbooks

Download Ansible playbooks that you can use to install OpenShift Container Platform on your own Red Hat OpenStack Platform (RHOSP) infrastructure.

Prerequisites

- The curl command-line tool is available on your machine.

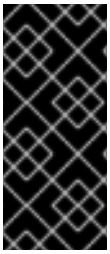
Procedure

- To download the playbooks to your working directory, run the following script from a command line:

```
$ xargs -n 1 curl -O <<< '
      https://raw.githubusercontent.com/openshift/installer/release-
4.11/upi/openstack/bootstrap.yaml
      https://raw.githubusercontent.com/openshift/installer/release-
4.11/upi/openstack/common.yaml
      https://raw.githubusercontent.com/openshift/installer/release-
4.11/upi/openstack/compute-nodes.yaml
      https://raw.githubusercontent.com/openshift/installer/release-4.11/upi/openstack/control-
plane.yaml
      https://raw.githubusercontent.com/openshift/installer/release-
4.11/upi/openstack/inventory.yaml
      https://raw.githubusercontent.com/openshift/installer/release-
```

```
4.11/upi/openstack/network.yaml
    https://raw.githubusercontent.com/openshift/installer/release-
4.11/upi/openstack/security-groups.yaml
    https://raw.githubusercontent.com/openshift/installer/release-4.11/upi/openstack/down-
bootstrap.yaml
    https://raw.githubusercontent.com/openshift/installer/release-4.11/upi/openstack/down-
compute-nodes.yaml
    https://raw.githubusercontent.com/openshift/installer/release-4.11/upi/openstack/down-
control-plane.yaml
    https://raw.githubusercontent.com/openshift/installer/release-4.11/upi/openstack/down-
load-balancers.yaml
    https://raw.githubusercontent.com/openshift/installer/release-4.11/upi/openstack/down-
network.yaml
    https://raw.githubusercontent.com/openshift/installer/release-4.11/upi/openstack/down-
security-groups.yaml
    https://raw.githubusercontent.com/openshift/installer/release-4.11/upi/openstack/down-
containers.yaml'
```

The playbooks are downloaded to your machine.



IMPORTANT

During the installation process, you can modify the playbooks to configure your deployment.

Retain all playbooks for the life of your cluster. You must have the playbooks to remove your OpenShift Container Platform cluster from RHOSP.

IMPORTANT

You must match any edits you make in the **bootstrap.yaml**, **compute-nodes.yaml**, **control-plane.yaml**, **network.yaml**, and **security-groups.yaml** files to the corresponding playbooks that are prefixed with **down-**. For example, edits to the **bootstrap.yaml** file must be reflected in the **down-bootstrap.yaml** file, too. If you do not edit both files, the supported cluster removal process will fail.

19.6.7. Obtaining the installation program

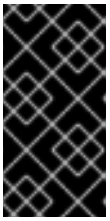
Before you install OpenShift Container Platform, download the installation file on a local computer.

Prerequisites

- You have a computer that runs Linux or macOS, with 500 MB of local disk space.

Procedure

1. Access the Infrastructure Provider page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program that corresponds with your host operating system and architecture, and place the file in the directory where you will store the installation configuration files.



IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.

IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation pull secret from the Red Hat OpenShift Cluster Manager . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

19.6.8. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the **~/.ssh/authorized_keys** list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The **./openshift-install gather** command also requires the SSH public key to be in place on the cluster nodes.

IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.

NOTE

You must use a local key, not one that you configured with platform-specific approaches such as AWS key pairs.

Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N '' -f <path>/<file_name> 1
```

1 Specify the path and file name, such as ~/**.ssh/id_ed25519**, of the new SSH key. If you have an existing key pair, ensure your public key is in the your ~/**.ssh** directory.

NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS validated or Modules In Process cryptographic libraries on the **x86_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the ~/**.ssh/id_ed25519.pub** public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the **./openshift-install gather** command.

NOTE

On some distributions, default SSH private key identities such as ~/**.ssh/id_rsa** and ~/**.ssh/id_dsa** are managed automatically.

a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

Example output

```
Agent pid 31874
```

NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

1 Specify the path and file name for your SSH private key, such as **~/.ssh/id_ed25519**

Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

19.6.9. Creating the Red Hat Enterprise Linux CoreOS (RHCOS) image

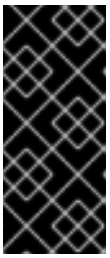
The OpenShift Container Platform installation program requires that a Red Hat Enterprise Linux CoreOS (RHCOS) image be present in the Red Hat OpenStack Platform (RHOSP) cluster. Retrieve the latest RHCOS image, then upload it using the RHOSP CLI.

Prerequisites

- The RHOSP CLI is installed.

Procedure

1. Log in to the Red Hat Customer Portal's Product Downloads page.
2. Under **Version**, select the most recent release of OpenShift Container Platform 4.11 for Red Hat Enterprise Linux (RHEL) 8.



IMPORTANT

The RHCOS images might not change with every release of OpenShift Container Platform. You must download images with the highest version that is less than or equal to the OpenShift Container Platform version that you install. Use the image versions that match your OpenShift Container Platform version if they are available.

3. Download the *Red Hat Enterprise Linux CoreOS (RHCOS) - OpenStack Image (QCOW)* .
4. Decompress the image.

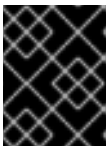
NOTE

You must decompress the RHOSP image before the cluster can use it. The name of the downloaded file might not contain a compression extension, like **.gz** or **.tgz**. To find out if or how the file is compressed, in a command line, enter:

```
$ file <name_of_downloaded_file>
```

5. From the image that you downloaded, create an image that is named **rhcos** in your cluster by using the RHOSP CLI:

```
$ openstack image create --container-format=bare --disk-format=qcow2 --file rhcos-
${RHCOS_VERSION}-openstack.qcow2 rhcos
```



IMPORTANT

Depending on your RHOSP environment, you might be able to upload the image in either **.raw** or **.qcow2** formats. If you use Ceph, you must use the **.raw** format.

WARNING

If the installation program finds multiple images with the same name, it chooses one of them at random. To avoid this behavior, create unique names for resources in RHOSP.

After you upload the image to RHOSP, it is usable in the installation process.

19.6.10. Verifying external network access

The OpenShift Container Platform installation process requires external network access. You must provide an external network value to it, or deployment fails. Before you begin the process, verify that a network with the external router type exists in Red Hat OpenStack Platform (RHOSP).

Prerequisites

- Configure OpenStack's networking service to have DHCP agents forward instances' DNS queries

Procedure

1. Using the RHOSP CLI, verify the name and ID of the 'External' network:

```
$ openstack network list --long -c ID -c Name -c "Router Type"
```

Example output

```
+--------------------------------------+----------------+-------------+
| ID                                   | Name           | Router Type |
+--------------------------------------+----------------+-------------+
| 148a8023-62a7-4672-b018-003462f8d7dc | public_network | External    |
+--------------------------------------+----------------+-------------+
```

A network with an external router type appears in the network list. If at least one does not, see Creating a default floating IP network and Creating a default provider network .

NOTE

If the Neutron trunk service plugin is enabled, a trunk port is created by default. For more information, see Neutron trunk port .

19.6.11. Enabling access to the environment

At deployment, all OpenShift Container Platform machines are created in a Red Hat OpenStack Platform (RHOSP)-tenant network. Therefore, they are not accessible directly in most RHOSP deployments.

You can configure OpenShift Container Platform API and application access by using floating IP addresses (FIPs) during installation. You can also complete an installation without configuring FIPs, but the installer will not configure a way to reach the API or applications externally.

19.6.11.1. Enabling access with floating IP addresses

Create floating IP (FIP) addresses for external access to the OpenShift Container Platform API, cluster applications, and the bootstrap process.

Procedure

1. Using the Red Hat OpenStack Platform (RHOSP) CLI, create the API FIP:

```
$ openstack floating ip create --description "API <cluster_name>.<base_domain>"
<external_network>
```

2. Using the Red Hat OpenStack Platform (RHOSP) CLI, create the apps, or Ingress, FIP:

```
$ openstack floating ip create --description "Ingress <cluster_name>.<base_domain>"
<external_network>
```

3. By using the Red Hat OpenStack Platform (RHOSP) CLI, create the bootstrap FIP:

```
$ openstack floating ip create --description "bootstrap machine" <external_network>
```

4. Add records that follow these patterns to your DNS server for the API and Ingress FIPs:

```
api.<cluster_name>.<base_domain>.  IN  A  <API_FIP>
*.apps.<cluster_name>.<base_domain>. IN  A <apps_FIP>
```

NOTE

If you do not control the DNS server, you can access the cluster by adding the cluster domain names such as the following to your **/etc/hosts** file:

- **<api_floating_ip> api.<cluster_name>.<base_domain>**
- **<application_floating_ip> grafana-openshift-monitoring.apps.<cluster_name>.<base_domain>**
- **<application_floating_ip> prometheus-k8s-openshift-monitoring.apps.<cluster_name>.<base_domain>**
- **<application_floating_ip> oauth-openshift.apps.<cluster_name>.<base_domain>**
- **<application_floating_ip> console-openshift-console.apps.<cluster_name>.<base_domain>**
- **application_floating_ip integrated-oauth-server-openshift-authentication.apps.<cluster_name>.<base_domain>**

The cluster domain names in the **/etc/hosts** file grant access to the web console and the monitoring interface of your cluster locally. You can also use the **kubectl** or **oc**. You can access the user applications by using the additional entries pointing to the <application_floating_ip>. This action makes the API and applications accessible to only you, which is not suitable for production deployment, but does allow installation for development and testing.

5. Add the FIPs to the **inventory.yaml** file as the values of the following variables:
   - **os_api_fip**
   - **os_bootstrap_fip**
   - **os_ingress_fip**

If you use these values, you must also enter an external network as the value of the **os_external_network** variable in the **inventory.yaml** file.

TIP

You can make OpenShift Container Platform resources available outside of the cluster by assigning a floating IP address and updating your firewall configuration.

19.6.11.2. Completing installation without floating IP addresses

You can install OpenShift Container Platform on Red Hat OpenStack Platform (RHOSP) without providing floating IP addresses.

In the **inventory.yaml** file, do not define the following variables:

- **os_api_fip**
- **os_bootstrap_fip**

- **os_ingress_fip**

If you cannot provide an external network, you can also leave **os_external_network** blank. If you do not provide a value for **os_external_network**, a router is not created for you, and, without additional action, the installer will fail to retrieve an image from Glance. Later in the installation process, when you create network resources, you must configure external connectivity on your own.

If you run the installer with the **wait-for** command from a system that cannot reach the cluster API due to a lack of floating IP addresses or name resolution, installation fails. To prevent installation failure in these cases, you can use a proxy network or run the installer from a system that is on the same network as your machines.

NOTE

You can enable name resolution by creating DNS records for the API and Ingress ports. For example:

```
api.<cluster_name>.<base_domain>.  IN  A  <api_port_IP>
*.apps.<cluster_name>.<base_domain>. IN  A <ingress_port_IP>
```

If you do not control the DNS server, you can add the record to your **/etc/hosts** file. This action makes the API accessible to only you, which is not suitable for production deployment but does allow installation for development and testing.

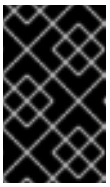
19.6.12. Defining parameters for the installation program

The OpenShift Container Platform installation program relies on a file that is called **clouds.yaml**. The file describes Red Hat OpenStack Platform (RHOSP) configuration parameters, including the project name, log in information, and authorization service URLs.

Procedure

1. Create the **clouds.yaml** file:

   - If your RHOSP distribution includes the Horizon web UI, generate a **clouds.yaml** file in it.



IMPORTANT

Remember to add a password to the **auth** field. You can also keep secrets in a separate file from **clouds.yaml**. OpenShift Container Platform does not support application credentials.

   - If your RHOSP distribution does not include the Horizon web UI, or you do not want to use Horizon, create the file yourself. For detailed information about **clouds.yaml**, see Config files in the RHOSP documentation.

```
clouds:
  shiftstack:
    auth:
      auth_url: http://10.10.14.42:5000/v3
      project_name: shiftstack
      username: <username>
      password: <password>
      user_domain_name: Default
```

```
    project_domain_name: Default
  dev-env:
    region_name: RegionOne
    auth:
      username: <username>
      password: <password>
      project_name: 'devonly'
      auth_url: 'https://10.10.14.22:5001/v2.0'
```

2. If your RHOSP installation uses self-signed certificate authority (CA) certificates for endpoint authentication:

   a. Copy the certificate authority file to your machine.

   b. Add the **cacerts** key to the **clouds.yaml** file. The value must be an absolute, non-root-accessible path to the CA certificate:

```
clouds:
  shiftstack:
    ...
    cacert: "/etc/pki/ca-trust/source/anchors/ca.crt.pem"
```

   TIP

   After you run the installer with a custom CA certificate, you can update the certificate by editing the value of the **ca-cert.pem** key in the **cloud-provider-config** keymap. On a command line, run:

```
$ oc edit configmap -n openshift-config cloud-provider-config
```

3. Place the **clouds.yaml** file in one of the following locations:

   a. The value of the **OS_CLIENT_CONFIG_FILE** environment variable

   b. The current directory

   c. A Unix-specific user configuration directory, for example **~/.config/openstack/clouds.yaml**

   d. A Unix-specific site configuration directory, for example **/etc/openstack/clouds.yaml**
   The installation program searches for **clouds.yaml** in that order.

19.6.13. Creating the installation configuration file

You can customize the OpenShift Container Platform cluster you install on Red Hat OpenStack Platform (RHOSP).

Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.
- Obtain service principal permissions at the subscription level.

Procedure

1. Create the **install-config.yaml** file.

   a. Change to the directory that contains the installation program and run the following command:

   ```
   $ ./openshift-install create install-config --dir <installation_directory> 1
   ```

   1 For **<installation_directory>**, specify the directory name to store the files that the installation program creates.

   When specifying the directory:

   - Verify that the directory has the **execute** permission. This permission is required to run Terraform binaries under the installation directory.
   - Use an empty directory. Some installation assets, such as bootstrap X.509 certificates, have short expiration intervals, therefore you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

   b. At the prompts, provide the configuration details for your cloud:

      i. Optional: Select an SSH key to use to access your cluster machines.

      NOTE

      For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

      ii. Select **openstack** as the platform to target.

      iii. Specify the Red Hat OpenStack Platform (RHOSP) external network name to use for installing the cluster.

      iv. Specify the floating IP address to use for external access to the OpenShift API.

      v. Specify a RHOSP flavor with at least 16 GB RAM to use for control plane nodes and 8 GB RAM for compute nodes.

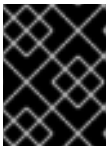
      vi. Select the base domain to deploy the cluster to. All DNS records will be sub-domains of this base and will also include the cluster name.

      vii. Enter a name for your cluster. The name must be 14 or fewer characters long.

      viii. Paste the pull secret from the Red Hat OpenShift Cluster Manager .

2. Modify the **install-config.yaml** file. You can find more information about the available parameters in the "Installation configuration parameters" section.

3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.



IMPORTANT

The **install-config.yaml** file is consumed during the installation process. If you want to reuse the file, you must back it up now.

You now have the file **install-config.yaml** in the directory that you specified.

19.6.14. Installation configuration parameters

Before you deploy an OpenShift Container Platform cluster, you provide parameter values to describe your account on the cloud platform that hosts your cluster and optionally customize your cluster's platform. When you create the **install-config.yaml** installation configuration file, you provide values for the required parameters through the command line. If you customize your cluster, you can modify the **install-config.yaml** file to provide more details about the platform.

NOTE

After installation, you cannot modify these parameters in the **install-config.yaml** file.

19.6.14.1. Required configuration parameters

Required installation configuration parameters are described in the following table:

Table 19.20. Required parameters

Parameter	Description	Values
apiVersion	The API version for the **install-config.yaml** content. The current version is **v1**. The installer may also support older API versions.	String
baseDomain	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the **baseDomain** and **metadata.name** parameter values that uses the **<metadata.name>.<baseDomain>** format.	A fully-qualified domain or subdomain name, such as **example.com**.
metadata	Kubernetes resource **ObjectMeta**, from which only the **name** parameter is consumed.	Object

Parameter	Description	Values
metadata.name	The name of the cluster. DNS records for the cluster are all subdomains of **{{.metadata.name}}.{{.baseDomain}}**.	String of lowercase letters, hyphens (**-**), and periods (**.**), such as **dev**. The string must be 14 characters or fewer long.
platform	The configuration for the specific platform upon which to perform the installation: **alibabacloud**, **aws**, **baremetal**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**. For additional information about **platform.<platform>** parameters, consult the table for your specific platform that follows.	Object
pullSecret	Get a pull secret from the Red Hat OpenShift Cluster Manager to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	{ "auths":{ "cloud.openshift.com":{ "auth":"b3Blb=", "email":"you@example.com" }, "quay.io":{ "auth":"b3Blb=", "email":"you@example.com" } } }

19.6.14.2. Network configuration parameters

You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

Only IPv4 addresses are supported.

NOTE

Globalnet is not supported with Red Hat OpenShift Data Foundation disaster recovery solutions. For regional disaster recovery scenarios, ensure that you use a nonoverlapping range of private IP addresses for the cluster and service networks in each cluster.

Table 19.21. Network parameters

Parameter	Description	Values
networking	The configuration for the cluster network.	Object  **NOTE** You cannot modify parameters specified by the **networking** object after installation.
networking.networkType	The cluster network provider Container Network Interface (CNI) cluster network provider to install.	Either **OpenShiftSDN** or **OVNKubernetes**. **OpenShiftSDN** is a CNI provider for all-Linux networks. **OVNKubernetes** is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is **OpenShiftSDN**.
networking.clusterNetwork	The IP address blocks for pods. The default value is **10.128.0.0/14** with a host prefix of **/23**. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: `networking:` `  clusterNetwork:` `  - cidr: 10.128.0.0/14` `    hostPrefix: 23`
networking.clusterNetwork.cidr	Required if you use **networking.clusterNetwork**. An IP address block. An IPv4 network.	An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between **0** and **32**.
networking.clusterNetwork.hostPrefix	The subnet prefix length to assign to each individual node. For example, if **hostPrefix** is set to **23** then each node is assigned a **/23** subnet out of the given **cidr**. A **hostPrefix** value of **23** provides 510 (2^(32 - 23) - 2) pod IP addresses.	A subnet prefix. The default value is **23**.
networking.serviceNetwork	The IP address block for services. The default value is **172.30.0.0/16**. The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.	An array with an IP address block in CIDR format. For example: `networking:` `  serviceNetwork:` `  - 172.30.0.0/16`

Parameter	Description	Values
networking.machineNetwork	The IP address blocks for machines. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: `networking:` `  machineNetwork:` `  - cidr: 10.0.0.0/16`
networking.machineNetwork.cidr	Required if you use **networking.machineNetwork**. An IP address block. The default value is **10.0.0.0/16** for all platforms other than libvirt. For libvirt, the default value is **192.168.126.0/24**.	An IP network block in CIDR notation. For example, **10.0.0.0/16**. **NOTE** Set the **networking.machineNetwork** to match the CIDR that the preferred NIC resides in.

19.6.14.3. Optional configuration parameters

Optional installation configuration parameters are described in the following table:

Table 19.22. Optional parameters

Parameter	Description	Values
additionalTrustBundle	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String
capabilities	Controls the installation of optional core cluster components. You can reduce the footprint of your OpenShift Container Platform cluster by disabling optional components.	String array

Parameter	Description	Values
capabilities.baselineCapabilitySet	Selects an initial set of optional capabilities to enable. Valid values are **None**, **v4.11** and **vCurrent**. **v4.11** enables the **baremetal** Operator, the **marketplace** Operator, and the **openshift-samples** content. **vCurrent** installs the recommended set of capabilities for the current version of OpenShift Container Platform. The default value is **vCurrent**.	String
capabilities.additionalEnabledCapabilities	Extends the set of optional capabilities beyond what you specify in **baselineCapabilitySet**. Valid values are **baremetal**, **marketplace** and **openshift-samples**. You may specify multiple capabilities in this parameter.	String array
cgroupsV2	Enables Linux control groups version 2 (cgroups v2) on specific nodes in your cluster. The OpenShift Container Platform process for enabling cgroups v2 disables all cgroup version 1 controllers and hierarchies. The OpenShift Container Platform cgroups version 2 feature is in Developer Preview and is not supported by Red Hat at this time.	**true**
compute	The configuration for the machines that comprise the compute nodes.	Array of **MachinePool** objects.
compute.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** (the default).	String

Parameter	Description	Values
compute.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  **IMPORTANT** If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
compute.name	Required if you use **compute**. The name of the machine pool.	**worker**
compute.platform	Required if you use **compute**. Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the **controlPlane.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
compute.replicas	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to **2**. The default value is **3**.
controlPlane	The configuration for the machines that comprise the control plane.	Array of **MachinePool** objects.
controlPlane.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** (the default).	String

Parameter	Description	Values
controlPlane.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  **IMPORTANT** If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
controlPlane.name	Required if you use **controlPlane**. The name of the machine pool.	**master**
controlPlane.platform	Required if you use **controlPlane**. Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the **compute.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
controlPlane.replicas	The number of control plane machines to provision.	The only supported value is **3**, which is the default value.

Parameter	Description	Values
credentialsMode	The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported.  **NOTE** Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the *Cloud Credential Operator* entry in the *Cluster Operators reference* content.  **NOTE** If your AWS account has service control policies (SCP) enabled, you must configure the **credentialsMode** parameter to **Mint**, **Passthrough** or **Manual**.	**Mint**, **Passthrough**, **Manual** or an empty string (**""**).
fips	Enable or disable FIPS mode. The default is **false** (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.	**false** or **true**

Parameter	Description	Values
	IMPORTANT  To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.  **NOTE** If you are using Azure File storage, you cannot enable FIPS mode.	
imageContentSources	Sources and repositories for the release-image content.	Array of objects. Includes a **source** and, optionally, **mirrors**, as described in the following rows of this table.
imageContentSources.source	Required if you use **imageContentSources**. Specify the repository that users refer to, for example, in image pull specifications.	String
imageContentSources.mirrors	Specify one or more repositories that may also contain the same images.	Array of strings

Parameter	Description	Values
publish	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	**Internal** or **External**. The default value is **External**. Setting this field to **Internal** is not supported on non-cloud platforms and IBM Cloud VPC.  **IMPORTANT** If the value of the field is set to **Internal**, the cluster will become non-functional. For more information, refer to BZ#1953035.
sshKey	The SSH key to authenticate access to your cluster machines.  **NOTE** For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.	For example, **sshKey: ssh-ed25519 AAAA..**.

19.6.14.4. Additional Red Hat OpenStack Platform (RHOSP) configuration parameters

Additional RHOSP configuration parameters are described in the following table:

Table 19.23. Additional RHOSP parameters

Parameter	Description	Values
compute.platform.openstack.rootVolume.size	For compute machines, the size in gigabytes of the root volume. If you do not set this value, machines use ephemeral storage.	Integer, for example **30**.
compute.platform.openstack.rootVolume.type	For compute machines, the root volume's type.	String, for example **performance**.
controlPlane.platform.openstack.rootVolume.size	For control plane machines, the size in gigabytes of the root volume. If you do not set this value, machines use ephemeral storage.	Integer, for example **30**.
controlPlane.platform.openstack.rootVolume.type	For control plane machines, the root volume's type.	String, for example **performance**.
platform.openstack.cloud	The name of the RHOSP cloud to use from the list of clouds in the **clouds.yaml** file.	String, for example **MyCloud**.
platform.openstack.externalNetwork	The RHOSP external network name to be used for installation.	String, for example **external**.
platform.openstack.computeFlavor	The RHOSP flavor to use for control plane and compute machines. This property is deprecated. To use a flavor as the default for all machine pools, add it as the value of the **type** key in the **platform.openstack.defaultMachinePlatform** property. You can also set a flavor value for each machine pool individually.	String, for example **m1.xlarge**.

19.6.14.5. Optional RHOSP configuration parameters

Optional RHOSP configuration parameters are described in the following table:

Table 19.24. Optional RHOSP parameters

Parameter	Description	Values
compute.platform.openstack.additionalNetworkIDs	Additional networks that are associated with compute machines. Allowed address pairs are not created for additional networks.	A list of one or more UUIDs as strings. For example, **fa806b2f-ac49-4bce-b9db-124bc64209bf**.
compute.platform.openstack.additionalSecurityGroupIDs	Additional security groups that are associated with compute machines.	A list of one or more UUIDs as strings. For example, **7ee219f3-d2e9-48a1-96c2-e7429f1b0da7**.
compute.platform.openstack.zones	RHOSP Compute (Nova) availability zones (AZs) to install machines on. If this parameter is not set, the installer relies on the default settings for Nova that the RHOSP administrator configured. On clusters that use Kuryr, RHOSP Octavia does not support availability zones. Load balancers and, if you are using the Amphora provider driver, OpenShift Container Platform services that rely on Amphora VMs, are not created according to the value of this property.	A list of strings. For example, **["zone-1", "zone-2"]**.
compute.platform.openstack.rootVolume.zones	For compute machines, the availability zone to install root volumes on. If you do not set a value for this parameter, the installer selects the default availability zone.	A list of strings, for example **["zone-1", "zone-2"]**.

Parameter	Description	Values
compute.platform.openstack.serverGroupPolicy	Server group policy to apply to the group that will contain the compute machines in the pool. You cannot change server group policies or affiliations after creation. Supported options include **anti-affinity**, **soft-affinity**, and **soft-anti-affinity**. The default value is **soft-anti-affinity**. An **affinity** policy prevents migrations and therefore affects RHOSP upgrades. The **affinity** policy is not supported. If you use a strict **anti-affinity** policy, an additional RHOSP host is required during instance migration.	A server group policy to apply to the machine pool. For example, **soft-affinity**.
controlPlane.platform.openstack.additionalNetworkIDs	Additional networks that are associated with control plane machines. Allowed address pairs are not created for additional networks.	A list of one or more UUIDs as strings. For example, **fa806b2f-ac49-4bce-b9db-124bc64209bf**.
controlPlane.platform.openstack.additionalSecurityGroupIDs	Additional security groups that are associated with control plane machines.	A list of one or more UUIDs as strings. For example, **7ee219f3-d2e9-48a1-96c2-e7429f1b0da7**.

Parameter	Description	Values
controlPlane.platform.openstack.zones	RHOSP Compute (Nova) availability zones (AZs) to install machines on. If this parameter is not set, the installer relies on the default settings for Nova that the RHOSP administrator configured. On clusters that use Kuryr, RHOSP Octavia does not support availability zones. Load balancers and, if you are using the Amphora provider driver, OpenShift Container Platform services that rely on Amphora VMs, are not created according to the value of this property.	A list of strings. For example, **["zone-1", "zone-2"]**.
controlPlane.platform.openstack.rootVolume.zones	For control plane machines, the availability zone to install root volumes on. If you do not set this value, the installer selects the default availability zone.	A list of strings, for example **["zone-1", "zone-2"]**.
controlPlane.platform.openstack.serverGroupPolicy	Server group policy to apply to the group that will contain the control plane machines in the pool. You cannot change server group policies or affiliations after creation. Supported options include **anti-affinity**, **soft-affinity**, and **soft-anti-affinity**. The default value is **soft-anti-affinity**. An **affinity** policy prevents migrations, and therefore affects RHOSP upgrades. The **affinity** policy is not supported. If you use a strict **anti-affinity** policy, an additional RHOSP host is required during instance migration.	A server group policy to apply to the machine pool. For example, **soft-affinity**.

Parameter	Description	Values
platform.openstack.clusterOSImage	The location from which the installer downloads the RHCOS image. You must set this parameter to perform an installation in a restricted network.	An HTTP or HTTPS URL, optionally with an SHA-256 checksum. For example, **http://mirror.example.com/images/rhcos-43.81.201912131630.0-openstack.x86_64.qcow2.gz?sha256=ffebbd68e8a1f2a245ca19522c16c86f67f9ac8e4e0c1f0a812b068b16f7265d**. The value can also be the name of an existing Glance image, for example **my-rhcos**.
platform.openstack.clusterOSImageProperties	Properties to add to the installer-uploaded ClusterOSImage in Glance. This property is ignored if **platform.openstack.clusterOSImage** is set to an existing Glance image. You can use this property to exceed the default persistent volume (PV) limit for RHOSP of 26 PVs per node. To exceed the limit, set the **hw_scsi_model** property value to **virtio-scsi** and the **hw_disk_bus** value to **scsi**. You can also use this property to enable the QEMU guest agent by including the **hw_qemu_guest_agent** property with a value of **yes**.	A list of key-value string pairs. For example, **["hw_scsi_model": "virtio-scsi", "hw_disk_bus": "scsi"]**.
platform.openstack.defaultMachinePlatform	The default machine pool platform configuration.	<pre>{ "type": "ml.large", "rootVolume": { "size": 30, "type": "performance" } }</pre>
platform.openstack.ingressFloatingIP	An existing floating IP address to associate with the Ingress port. To use this property, you must also define the **platform.openstack.externalNetwork** property.	An IP address, for example **128.0.0.1**.

Parameter	Description	Values
platform.openstack.apiFloatingIP	An existing floating IP address to associate with the API load balancer. To use this property, you must also define the **platform.openstack.externalNetwork** property.	An IP address, for example **128.0.0.1**.
platform.openstack.externalDNS	IP addresses for external DNS servers that cluster instances use for DNS resolution.	A list of IP addresses as strings. For example, **["8.8.8.8", "192.168.1.12"]**.
platform.openstack.machinesSubnet	The UUID of a RHOSP subnet that the cluster's nodes use. Nodes and virtual IP (VIP) ports are created on this subnet. The first item in **networking.machineNetwork** must match the value of **machinesSubnet**. If you deploy to a custom subnet, you cannot specify an external DNS server to the OpenShift Container Platform installer. Instead, add DNS to the subnet in RHOSP.	A UUID as a string. For example, **fa806b2f-ac49-4bce-b9db-124bc64209bf**.

19.6.14.6. Custom subnets in RHOSP deployments

Optionally, you can deploy a cluster on a Red Hat OpenStack Platform (RHOSP) subnet of your choice. The subnet's GUID is passed as the value of **platform.openstack.machinesSubnet** in the **install-config.yaml** file.

This subnet is used as the cluster's primary subnet. By default, nodes and ports are created on it. You can create nodes and ports on a different RHOSP subnet by setting the value of the **platform.openstack.machinesSubnet** property to the subnet's UUID.

Before you run the OpenShift Container Platform installer with a custom subnet, verify that your configuration meets the following requirements:

- The subnet that is used by **platform.openstack.machinesSubnet** has DHCP enabled.
- The CIDR of **platform.openstack.machinesSubnet** matches the CIDR of **networking.machineNetwork**.
- The installation program user has permission to create ports on this network, including ports with fixed IP addresses.

Clusters that use custom subnets have the following limitations:

- If you plan to install a cluster that uses floating IP addresses, the **platform.openstack.machinesSubnet** subnet must be attached to a router that is connected to the **externalNetwork** network.
- If the **platform.openstack.machinesSubnet** value is set in the **install-config.yaml** file, the installation program does not create a private network or subnet for your RHOSP machines.
- You cannot use the **platform.openstack.externalDNS** property at the same time as a custom subnet. To add DNS to a cluster that uses a custom subnet, configure DNS on the RHOSP network.

NOTE

By default, the API VIP takes x.x.x.5 and the Ingress VIP takes x.x.x.7 from your network's CIDR block. To override these default values, set values for **platform.openstack.apiVIP** and **platform.openstack.ingressVIP** that are outside of the DHCP allocation pool.

IMPORTANT

The CIDR ranges for networks are not adjustable after cluster installation. Red Hat does not provide direct guidance on determining the range during cluster installation because it requires careful consideration of the number of created pods per namespace.

19.6.14.7. Sample customized install-config.yaml file for RHOSP with Kuryr

To deploy with Kuryr SDN instead of the default OpenShift SDN, you must modify the **install-config.yaml** file to include **Kuryr** as the desired **networking.networkType** and proceed with the default OpenShift Container Platform SDN installation steps. This sample **install-config.yaml** demonstrates all of the possible Red Hat OpenStack Platform (RHOSP) customization options.

IMPORTANT

This sample file is provided for reference only. You must obtain your **install-config.yaml** file by using the installation program.

```
apiVersion: v1
baseDomain: example.com
controlPlane:
  name: master
  platform: {}
  replicas: 3
compute:
- name: worker
  platform:
    openstack:
      type: ml.large
  replicas: 3
metadata:
  name: example
networking:
  clusterNetwork:
  - cidr: 10.128.0.0/14
    hostPrefix: 23
  machineNetwork:
```

```
  - cidr: 10.0.0.0/16
  serviceNetwork:
  - 172.30.0.0/16 1
  networkType: Kuryr
platform:
  openstack:
    cloud: mycloud
    externalNetwork: external
    computeFlavor: m1.xlarge
    apiFloatingIP: 128.0.0.1
    trunkSupport: true 2
    octaviaSupport: true 3
pullSecret: '{"auths": ...}'
sshKey: ssh-ed25519 AAAA...
```

1 The Amphora Octavia driver creates two ports per load balancer. As a result, the service subnet that the installer creates is twice the size of the CIDR that is specified as the value of the **serviceNetwork** property. The larger range is required to prevent IP address conflicts.

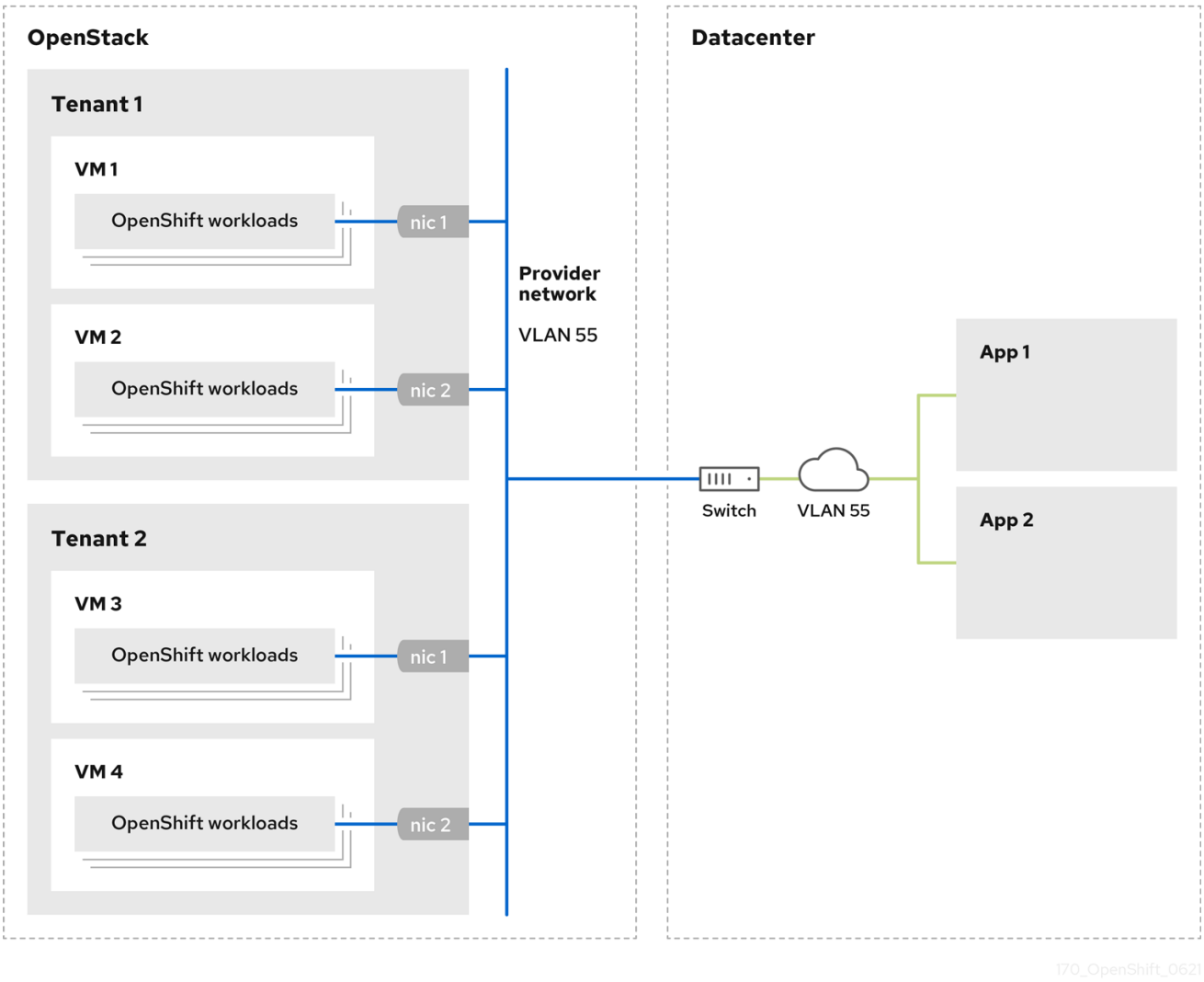
2 3 Both **trunkSupport** and **octaviaSupport** are automatically discovered by the installer, so there is no need to set them. But if your environment does not meet both requirements, Kuryr SDN will not properly work. Trunks are needed to connect the pods to the RHOSP network and Octavia is required to create the OpenShift Container Platform services.

19.6.14.8. Cluster deployment on RHOSP provider networks

You can deploy your OpenShift Container Platform clusters on Red Hat OpenStack Platform (RHOSP) with a primary network interface on a provider network. Provider networks are commonly used to give projects direct access to a public network that can be used to reach the internet. You can also share provider networks among projects as part of the network creation process.

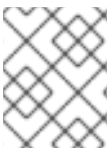
RHOSP provider networks map directly to an existing physical network in the data center. A RHOSP administrator must create them.

In the following example, OpenShift Container Platform workloads are connected to a data center by using a provider network:



OpenShift Container Platform clusters that are installed on provider networks do not require tenant networks or floating IP addresses. The installer does not create these resources during installation.

Example provider network types include flat (untagged) and VLAN (802.1Q tagged).



NOTE

A cluster can support as many provider network connections as the network type allows. For example, VLAN networks typically support up to 4096 connections.

You can learn more about provider and tenant networks in the RHOSP documentation.

19.6.14.8.1. RHOSP provider network requirements for cluster installation

Before you install an OpenShift Container Platform cluster, your Red Hat OpenStack Platform (RHOSP) deployment and provider network must meet a number of conditions:

- The RHOSP networking service (Neutron) is enabled and accessible through the RHOSP networking API.
- The RHOSP networking service has the port security and allowed address pairs extensions enabled.

- The provider network can be shared with other tenants.

  TIP

  Use the **openstack network create** command with the **--share** flag to create a network that can be shared.

- The RHOSP project that you use to install the cluster must own the provider network, as well as an appropriate subnet.

  TIP

  To create a network for a project that is named "openshift," enter the following command

  ```
  $ openstack network create --project openshift
  ```

  To create a subnet for a project that is named "openshift," enter the following command

  ```
  $ openstack subnet create --project openshift
  ```

  To learn more about creating networks on RHOSP, read the provider networks documentation.

  If the cluster is owned by the **admin** user, you must run the installer as that user to create ports on the network.

  IMPORTANT

  Provider networks must be owned by the RHOSP project that is used to create the cluster. If they are not, the RHOSP Compute service (Nova) cannot request a port from that network.

- Verify that the provider network can reach the RHOSP metadata service IP address, which is **169.254.169.254** by default.
  Depending on your RHOSP SDN and networking service configuration, you might need to provide the route when you create the subnet. For example:

  ```
  $ openstack subnet create --dhcp --host-route
  destination=169.254.169.254/32,gateway=192.0.2.2 ...
  ```

- Optional: To secure the network, create role-based access control (RBAC) rules that limit network access to a single project.

19.6.14.8.2. Deploying a cluster that has a primary interface on a provider network

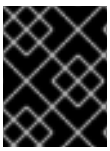
You can deploy an OpenShift Container Platform cluster that has its primary network interface on an Red Hat OpenStack Platform (RHOSP) provider network.

Prerequisites

- Your Red Hat OpenStack Platform (RHOSP) deployment is configured as described by "RHOSP provider network requirements for cluster installation".

Procedure

1. In a text editor, open the **install-config.yaml** file.
2. Set the value of the **platform.openstack.apiVIP** property to the IP address for the API VIP.
3. Set the value of the **platform.openstack.ingressVIP** property to the IP address for the Ingress VIP.
4. Set the value of the **platform.openstack.machinesSubnet** property to the UUID of the provider network subnet.
5. Set the value of the **networking.machineNetwork.cidr** property to the CIDR block of the provider network subnet.



IMPORTANT

The **platform.openstack.apiVIP** and **platform.openstack.ingressVIP** properties must both be unassigned IP addresses from the **networking.machineNetwork.cidr** block.

Section of an installation configuration file for a cluster that relies on a RHOSP provider network

```
...
platform:
  openstack:
    apiVIP: 192.0.2.13
    ingressVIP: 192.0.2.23
    machinesSubnet: fa806b2f-ac49-4bce-b9db-124bc64209bf
    # ...
networking:
  machineNetwork:
  - cidr: 192.0.2.0/24
```

WARNING

You cannot set the **platform.openstack.externalNetwork** or **platform.openstack.externalDNS** parameters while using a provider network for the primary network interface.

When you deploy the cluster, the installer uses the **install-config.yaml** file to deploy the cluster on the provider network.

TIP

You can add additional networks, including provider networks, to the **platform.openstack.additionalNetworkIDs** list.

After you deploy your cluster, you can attach pods to additional networks. For more information, see Understanding multiple networks.

19.6.14.9. Kuryr ports pools

A Kuryr ports pool maintains a number of ports on standby for pod creation.

Keeping ports on standby minimizes pod creation time. Without ports pools, Kuryr must explicitly request port creation or deletion whenever a pod is created or deleted.

The Neutron ports that Kuryr uses are created in subnets that are tied to namespaces. These pod ports are also added as subports to the primary port of OpenShift Container Platform cluster nodes.

Because Kuryr keeps each namespace in a separate subnet, a separate ports pool is maintained for each namespace-worker pair.

Prior to installing a cluster, you can set the following parameters in the **cluster-network-03-config.yml** manifest file to configure ports pool behavior:

- The **enablePortPoolsPrepopulation** parameter controls pool prepopulation, which forces Kuryr to add Neutron ports to the pools when the first pod that is configured to use the dedicated network for pods is created in a namespace. The default value is **false**.
- The **poolMinPorts** parameter is the minimum number of free ports that are kept in the pool. The default value is **1**.
- The **poolMaxPorts** parameter is the maximum number of free ports that are kept in the pool. A value of **0** disables that upper bound. This is the default setting.
  If your OpenStack port quota is low, or you have a limited number of IP addresses on the pod network, consider setting this option to ensure that unneeded ports are deleted.
- The **poolBatchPorts** parameter defines the maximum number of Neutron ports that can be created at once. The default value is **3**.

19.6.14.10. Adjusting Kuryr ports pools during installation

During installation, you can configure how Kuryr manages Red Hat OpenStack Platform (RHOSP) Neutron ports to control the speed and efficiency of pod creation.

Prerequisites

- Create and modify the **install-config.yaml** file.

Procedure

1. From a command line, create the manifest files:

```
$ ./openshift-install create manifests --dir <installation_directory> 1
```

1 For **<installation_directory>**, specify the name of the directory that contains the **install-config.yaml** file for your cluster.

2. Create a file that is named **cluster-network-03-config.yml** in the **<installation_directory>/manifests/** directory:

```
$ touch <installation_directory>/manifests/cluster-network-03-config.yml 1
```

1 For **<installation_directory>**, specify the directory name that contains the **manifests/** directory for your cluster.

After creating the file, several network configuration files are in the **manifests/** directory, as shown:

```
$ ls <installation_directory>/manifests/cluster-network-*
```

Example output

```
cluster-network-01-crd.yml
cluster-network-02-config.yml
cluster-network-03-config.yml
```

3. Open the **cluster-network-03-config.yml** file in an editor, and enter a custom resource (CR) that describes the Cluster Network Operator configuration that you want:

```
$ oc edit networks.operator.openshift.io cluster
```

4. Edit the settings to meet your requirements. The following file is provided as an example:

```
apiVersion: operator.openshift.io/v1
kind: Network
metadata:
  name: cluster
spec:
  clusterNetwork:
  - cidr: 10.128.0.0/14
    hostPrefix: 23
  serviceNetwork:
  - 172.30.0.0/16
  defaultNetwork:
    type: Kuryr
    kuryrConfig:
      enablePortPoolsPrepopulation: false 1
      poolMinPorts: 1 2
      poolBatchPorts: 3 3
      poolMaxPorts: 5 4
      openstackServiceNetwork: 172.30.0.0/15 5
```

1 Set **enablePortPoolsPrepopulation** to **true** to make Kuryr create new Neutron ports when the first pod on the network for pods is created in a namespace. This setting raises the Neutron ports quota but can reduce the time that is required to spawn pods. The default value is **false**.

2 Kuryr creates new ports for a pool if the number of free ports in that pool is lower than the value of **poolMinPorts**. The default value is **1**.

3 **poolBatchPorts** controls the number of new ports that are created if the number of free ports is lower than the value of **poolMinPorts**. The default value is **3**.

4 If the number of free ports in a pool is higher than the value of **poolMaxPorts**, Kuryr deletes them until the number matches that value. Setting this value to **0** disables this upper bound, preventing pools from shrinking. The default value is **0**.

5 The **openStackServiceNetwork** parameter defines the CIDR range of the network from which IP addresses are allocated to RHOSP Octavia's LoadBalancers.

If this parameter is used with the Amphora driver, Octavia takes two IP addresses from this network for each load balancer: one for OpenShift and the other for VRRP connections. Because these IP addresses are managed by OpenShift Container Platform and Neutron respectively, they must come from different pools. Therefore, the value of **openStackServiceNetwork** must be at least twice the size of the value of **serviceNetwork**, and the value of **serviceNetwork** must overlap entirely with the range that is defined by **openStackServiceNetwork**.

The CNO verifies that VRRP IP addresses that are taken from the range that is defined by this parameter do not overlap with the range that is defined by the **serviceNetwork** parameter.

If this parameter is not set, the CNO uses an expanded value of **serviceNetwork** that is determined by decrementing the prefix size by 1.

5. Save the **cluster-network-03-config.yml** file, and exit the text editor.

6. Optional: Back up the **manifests/cluster-network-03-config.yml** file. The installation program deletes the **manifests/** directory while creating the cluster.

19.6.14.11. Setting a custom subnet for machines

The IP range that the installation program uses by default might not match the Neutron subnet that you create when you install OpenShift Container Platform. If necessary, update the CIDR value for new machines by editing the installation configuration file.

Prerequisites

- You have the **install-config.yaml** file that was generated by the OpenShift Container Platform installation program.

Procedure

1. On a command line, browse to the directory that contains **install-config.yaml**.

2. From that directory, either run a script to edit the **install-config.yaml** file or update the file manually:

   - To set the value by using a script, run:

```
$ python -c '
import yaml;
path = "install-config.yaml";
```

```
data = yaml.safe_load(open(path));
data["networking"]["machineNetwork"] = [{"cidr": "192.168.0.0/18"}]; 1
open(path, "w").write(yaml.dump(data, default_flow_style=False))'
```

1 Insert a value that matches your intended Neutron subnet, e.g. **192.0.2.0/24**.

- To set the value manually, open the file and set the value of **networking.machineCIDR** to something that matches your intended Neutron subnet.

19.6.14.12. Emptying compute machine pools

To proceed with an installation that uses your own infrastructure, set the number of compute machines in the installation configuration file to zero. Later, you create these machines manually.

Prerequisites

- You have the **install-config.yaml** file that was generated by the OpenShift Container Platform installation program.

Procedure

1. On a command line, browse to the directory that contains **install-config.yaml**.
2. From that directory, either run a script to edit the **install-config.yaml** file or update the file manually:
   - To set the value by using a script, run:

```
$ python -c '
import yaml;
path = "install-config.yaml";
data = yaml.safe_load(open(path));
data["compute"][0]["replicas"] = 0;
open(path, "w").write(yaml.dump(data, default_flow_style=False))'
```

   - To set the value manually, open the file and set the value of **compute.<first entry>.replicas** to **0**.

19.6.14.13. Modifying the network type

By default, the installation program selects the **OpenShiftSDN** network type. To use Kuryr instead, change the value in the installation configuration file that the program generated.

Prerequisites

- You have the file **install-config.yaml** that was generated by the OpenShift Container Platform installation program

Procedure

1. In a command prompt, browse to the directory that contains **install-config.yaml**.
2. From that directory, either run a script to edit the **install-config.yaml** file or update the file manually:

- To set the value by using a script, run:

```
$ python -c '
import yaml;
path = "install-config.yaml";
data = yaml.safe_load(open(path));
data["networking"]["networkType"] = "Kuryr";
open(path, "w").write(yaml.dump(data, default_flow_style=False))'
```

- To set the value manually, open the file and set **networking.networkType** to **"Kuryr"**.

19.6.15. Creating the Kubernetes manifest and Ignition config files

Because you must modify some cluster definition files and manually start the cluster machines, you must generate the Kubernetes manifest and Ignition config files that the cluster needs to configure the machines.

The installation configuration file transforms into the Kubernetes manifests. The manifests wrap into the Ignition configuration files, which are later used to configure the cluster machines.

IMPORTANT

- The Ignition config files that the OpenShift Container Platform installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

Prerequisites

- You obtained the OpenShift Container Platform installation program.
- You created the **install-config.yaml** installation configuration file.

Procedure

1. Change to the directory that contains the OpenShift Container Platform installation program and generate the Kubernetes manifests for the cluster:

```
$ ./openshift-install create manifests --dir <installation_directory> 1
```

1 For **<installation_directory>**, specify the installation directory that contains the **install-config.yaml** file you created.

2. Remove the Kubernetes manifest files that define the control plane machines and compute machine sets:

```
$ rm -f openshift/99_openshift-cluster-api_master-machines-*.yaml openshift/99_openshift-cluster-api_worker-machineset-*.yaml
```

   Because you create and manage these resources yourself, you do not have to initialize them.

   - You can preserve the machine set files to create compute machines by using the machine API, but you must update references to them to match your environment.

3. Check that the **mastersSchedulable** parameter in the **<installation_directory>/manifests/cluster-scheduler-02-config.yml** Kubernetes manifest file is set to **false**. This setting prevents pods from being scheduled on the control plane machines:

   a. Open the **<installation_directory>/manifests/cluster-scheduler-02-config.yml** file.

   b. Locate the **mastersSchedulable** parameter and ensure that it is set to **false**.

   c. Save and exit the file.

4. To create the Ignition configuration files, run the following command from the directory that contains the installation program:

```
$ ./openshift-install create ignition-configs --dir <installation_directory> 1
```

   1 For **<installation_directory>**, specify the same installation directory.

   Ignition config files are created for the bootstrap, control plane, and compute nodes in the installation directory. The **kubeadmin-password** and **kubeconfig** files are created in the **./<installation_directory>/auth** directory:

```
.
├── auth
│   ├── kubeadmin-password
│   └── kubeconfig
├── bootstrap.ign
├── master.ign
├── metadata.json
└── worker.ign
```

5. Export the metadata file's **infraID** key as an environment variable:

```
$ export INFRA_ID=$(jq -r .infraID metadata.json)
```

TIP

Extract the **infraID** key from **metadata.json** and use it as a prefix for all of the RHOSP resources that you create. By doing so, you avoid name conflicts when making multiple deployments in the same project.

19.6.16. Preparing the bootstrap Ignition files

The OpenShift Container Platform installation process relies on bootstrap machines that are created from a bootstrap Ignition configuration file.

Edit the file and upload it. Then, create a secondary bootstrap Ignition configuration file that Red Hat OpenStack Platform (RHOSP) uses to download the primary file.

Prerequisites

- You have the bootstrap Ignition file that the installer program generates, **bootstrap.ign**.
- The infrastructure ID from the installer's metadata file is set as an environment variable (**$INFRA_ID**).
  - If the variable is not set, see **Creating the Kubernetes manifest and Ignition config files**
- You have an HTTP(S)-accessible way to store the bootstrap Ignition file.
  - The documented procedure uses the RHOSP image service (Glance), but you can also use the RHOSP storage service (Swift), Amazon S3, an internal HTTP server, or an ad hoc Nova server.

Procedure

1. Run the following Python script. The script modifies the bootstrap Ignition file to set the hostname and, if available, CA certificate file when it runs:

```
import base64
import json
import os

with open('bootstrap.ign', 'r') as f:
    ignition = json.load(f)

files = ignition['storage'].get('files', [])

infra_id = os.environ.get('INFRA_ID', 'openshift').encode()
hostname_b64 = base64.standard_b64encode(infra_id + b'-bootstrap\n').decode().strip()
files.append(
{
    'path': '/etc/hostname',
    'mode': 420,
    'contents': {
        'source': 'data:text/plain;charset=utf-8;base64,' + hostname_b64
    }
})

ca_cert_path = os.environ.get('OS_CACERT', '')
if ca_cert_path:
    with open(ca_cert_path, 'r') as f:
        ca_cert = f.read().encode()
        ca_cert_b64 = base64.standard_b64encode(ca_cert).decode().strip()

    files.append(
    {
        'path': '/opt/openshift/tls/cloud-ca-cert.pem',
        'mode': 420,
```

```
        'contents': {
            'source': 'data:text/plain;charset=utf-8;base64,' + ca_cert_b64
        }
    })

ignition['storage']['files'] = files;

with open('bootstrap.ign', 'w') as f:
    json.dump(ignition, f)
```

2. Using the RHOSP CLI, create an image that uses the bootstrap Ignition file:

```
$ openstack image create --disk-format=raw --container-format=bare --file bootstrap.ign
<image_name>
```

3. Get the image's details:

```
$ openstack image show <image_name>
```

Make a note of the **file** value; it follows the pattern **v2/images/<image_ID>/file**.

NOTE

Verify that the image you created is active.

4. Retrieve the image service's public address:

```
$ openstack catalog show image
```

5. Combine the public address with the image **file** value and save the result as the storage location. The location follows the pattern **<image_service_public_URL>/v2/images/<image_ID>/file**.

6. Generate an auth token and save the token ID:

```
$ openstack token issue -c id -f value
```

7. Insert the following content into a file called **$INFRA_ID-bootstrap-ignition.json** and edit the placeholders to match your own values:

```
{
  "ignition": {
    "config": {
      "merge": [{
        "source": "<storage_url>", 1
        "httpHeaders": [{
          "name": "X-Auth-Token", 2
          "value": "<token_ID>" 3
        }]
      }]
    },
    "security": {
      "tls": {
```

```
          "certificateAuthorities": [{
            "source": "data:text/plain;charset=utf-8;base64,<base64_encoded_certificate>" (4)
          }]
        }
      },
      "version": "3.2.0"
    }
  }
```

(1) Replace the value of **ignition.config.merge.source** with the bootstrap Ignition file storage URL.

(2) Set **name** in **httpHeaders** to **"X-Auth-Token"**.

(3) Set **value** in **httpHeaders** to your token's ID.

(4) If the bootstrap Ignition file server uses a self-signed certificate, include the base64-encoded certificate.

8. Save the secondary Ignition config file.

The bootstrap Ignition data will be passed to RHOSP during installation.

WARNING

The bootstrap Ignition file contains sensitive information, like **clouds.yaml** credentials. Ensure that you store it in a secure place, and delete it after you complete the installation process.

19.6.17. Creating control plane Ignition config files on RHOSP

Installing OpenShift Container Platform on Red Hat OpenStack Platform (RHOSP) on your own infrastructure requires control plane Ignition config files. You must create multiple config files.

NOTE

As with the bootstrap Ignition configuration, you must explicitly define a hostname for each control plane machine.

Prerequisites

- The infrastructure ID from the installation program's metadata file is set as an environment variable (**$INFRA_ID**).
  - If the variable is not set, see "Creating the Kubernetes manifest and Ignition config files".

Procedure

- On a command line, run the following Python script:

```
$ for index in $(seq 0 2); do
    MASTER_HOSTNAME="$INFRA_ID-master-$index\n"
    python -c "import base64, json, sys;
ignition = json.load(sys.stdin);
storage = ignition.get('storage', {});
files = storage.get('files', []);
files.append({'path': '/etc/hostname', 'mode': 420, 'contents': {'source':
'data:text/plain;charset=utf-8;base64,' +
base64.standard_b64encode(b'$MASTER_HOSTNAME').decode().strip(), 'verification': {}},
'filesystem': 'root'});
storage['files'] = files;
ignition['storage'] = storage
json.dump(ignition, sys.stdout)" <master.ign >"$INFRA_ID-master-$index-ignition.json"
done
```

You now have three control plane Ignition files: **<INFRA_ID>-master-0-ignition.json**, **<INFRA_ID>-master-1-ignition.json**, and **<INFRA_ID>-master-2-ignition.json**.

19.6.18. Creating network resources on RHOSP

Create the network resources that an OpenShift Container Platform on Red Hat OpenStack Platform (RHOSP) installation on your own infrastructure requires. To save time, run supplied Ansible playbooks that generate security groups, networks, subnets, routers, and ports.

Prerequisites

- Python 3 is installed on your machine.
- You downloaded the modules in "Downloading playbook dependencies".
- You downloaded the playbooks in "Downloading the installation playbooks".

Procedure

1. Optional: Add an external network value to the **inventory.yaml** playbook:

Example external network value in the inventory.yaml Ansible playbook

```
...
    # The public network providing connectivity to the cluster. If not
    # provided, the cluster external connectivity must be provided in another
    # way.

    # Required for os_api_fip, os_ingress_fip, os_bootstrap_fip.
    os_external_network: 'external'
...
```

IMPORTANT

If you did not provide a value for **os_external_network** in the **inventory.yaml** file, you must ensure that VMs can access Glance and an external connection yourself.

2. Optional: Add external network and floating IP (FIP) address values to the **inventory.yaml** playbook:

Example FIP values in the inventory.yaml Ansible playbook

```
...
    # OpenShift API floating IP address. If this value is non-empty, the
    # corresponding floating IP will be attached to the Control Plane to
    # serve the OpenShift API.
    os_api_fip: '203.0.113.23'

    # OpenShift Ingress floating IP address. If this value is non-empty, the
    # corresponding floating IP will be attached to the worker nodes to serve
    # the applications.
    os_ingress_fip: '203.0.113.19'

    # If this value is non-empty, the corresponding floating IP will be
    # attached to the bootstrap machine. This is needed for collecting logs
    # in case of install failure.
    os_bootstrap_fip: '203.0.113.20'
```

IMPORTANT

If you do not define values for **os_api_fip** and **os_ingress_fip**, you must perform postinstallation network configuration.

If you do not define a value for **os_bootstrap_fip**, the installer cannot download debugging information from failed installations.

See "Enabling access to the environment" for more information.

3. On a command line, create security groups by running the **security-groups.yaml** playbook:

```
$ ansible-playbook -i inventory.yaml security-groups.yaml
```

4. On a command line, create a network, subnet, and router by running the **network.yaml** playbook:

```
$ ansible-playbook -i inventory.yaml network.yaml
```

5. Optional: If you want to control the default resolvers that Nova servers use, run the RHOSP CLI command:

```
$ openstack subnet set --dns-nameserver <server_1> --dns-nameserver <server_2>
"$INFRA_ID-nodes"
```

19.6.19. Creating the bootstrap machine on RHOSP

Create a bootstrap machine and give it the network access it needs to run on Red Hat OpenStack Platform (RHOSP). Red Hat provides an Ansible playbook that you run to simplify this process.

Prerequisites

- You downloaded the modules in "Downloading playbook dependencies".
- You downloaded the playbooks in "Downloading the installation playbooks".
- The **inventory.yaml**, **common.yaml**, and **bootstrap.yaml** Ansible playbooks are in a common directory.
- The **metadata.json** file that the installation program created is in the same directory as the Ansible playbooks.

Procedure

1. On a command line, change the working directory to the location of the playbooks.
2. On a command line, run the **bootstrap.yaml** playbook:

```
$ ansible-playbook -i inventory.yaml bootstrap.yaml
```

3. After the bootstrap server is active, view the logs to verify that the Ignition files were received:

```
$ openstack console log show "$INFRA_ID-bootstrap"
```

19.6.20. Creating the control plane machines on RHOSP

Create three control plane machines by using the Ignition config files that you generated. Red Hat provides an Ansible playbook that you run to simplify this process.

Prerequisites

- You downloaded the modules in "Downloading playbook dependencies".
- You downloaded the playbooks in "Downloading the installation playbooks".
- The infrastructure ID from the installation program's metadata file is set as an environment variable (**$INFRA_ID**).
- The **inventory.yaml**, **common.yaml**, and **control-plane.yaml** Ansible playbooks are in a common directory.
- You have the three Ignition files that were created in "Creating control plane Ignition config files".

Procedure

1. On a command line, change the working directory to the location of the playbooks.
2. If the control plane Ignition config files aren't already in your working directory, copy them into it.
3. On a command line, run the **control-plane.yaml** playbook:

```
$ ansible-playbook -i inventory.yaml control-plane.yaml
```

4. Run the following command to monitor the bootstrapping process:

```
$ openshift-install wait-for bootstrap-complete
```

You will see messages that confirm that the control plane machines are running and have joined the cluster:

```
INFO API v1.24.0 up
INFO Waiting up to 30m0s for bootstrapping to complete...
...
INFO It is now safe to remove the bootstrap resources
```

19.6.21. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

Example output

```
system:admin
```

19.6.22. Deleting bootstrap resources from RHOSP

Delete the bootstrap resources that you no longer need.

Prerequisites

- You downloaded the modules in "Downloading playbook dependencies".
- You downloaded the playbooks in "Downloading the installation playbooks".
- The **inventory.yaml**, **common.yaml**, and **down-bootstrap.yaml** Ansible playbooks are in a common directory.

- The control plane machines are running.
  - If you do not know the status of the machines, see "Verifying cluster status".

Procedure

1. On a command line, change the working directory to the location of the playbooks.
2. On a command line, run the **down-bootstrap.yaml** playbook:

```
$ ansible-playbook -i inventory.yaml down-bootstrap.yaml
```

The bootstrap port, server, and floating IP address are deleted.

WARNING

If you did not disable the bootstrap Ignition file URL earlier, do so now.

19.6.23. Creating compute machines on RHOSP

After standing up the control plane, create compute machines. Red Hat provides an Ansible playbook that you run to simplify this process.

Prerequisites

- You downloaded the modules in "Downloading playbook dependencies".
- You downloaded the playbooks in "Downloading the installation playbooks".
- The **inventory.yaml**, **common.yaml**, and **compute-nodes.yaml** Ansible playbooks are in a common directory.
- The **metadata.json** file that the installation program created is in the same directory as the Ansible playbooks.
- The control plane is active.

Procedure

1. On a command line, change the working directory to the location of the playbooks.
2. On a command line, run the playbook:

```
$ ansible-playbook -i inventory.yaml compute-nodes.yaml
```

Next steps

- Approve the certificate signing requests for the machines.

19.6.24. Approving the certificate signing requests for your machines

When you add machines to a cluster, two pending certificate signing requests (CSRs) are generated for each machine that you added. You must confirm that these CSRs are approved or, if necessary, approve them yourself. The client requests must be approved first, followed by the server requests.

Prerequisites

- You added machines to your cluster.

Procedure

1. Confirm that the cluster recognizes the machines:

```
$ oc get nodes
```

Example output

```
NAME      STATUS    ROLES   AGE  VERSION
master-0  Ready     master  63m  v1.24.0
master-1  Ready     master  63m  v1.24.0
master-2  Ready     master  64m  v1.24.0
```

The output lists all of the machines that you created.

NOTE

The preceding output might not include the compute nodes, also known as worker nodes, until some CSRs are approved.

2. Review the pending CSRs and ensure that you see the client requests with the **Pending** or **Approved** status for each machine that you added to the cluster:

```
$ oc get csr
```

Example output

```
NAME        AGE     REQUESTOR                                                   CONDITION
csr-8b2br   15m     system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper   Pending
csr-8vnps   15m     system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper   Pending
...
```

In this example, two machines are joining the cluster. You might see more approved CSRs in the list.

3. If the CSRs were not approved, after all of the pending CSRs for the machines you added are in **Pending** status, approve the CSRs for your cluster machines:

NOTE

Because the CSRs rotate automatically, approve your CSRs within an hour of adding the machines to the cluster. If you do not approve them within an hour, the certificates will rotate, and more than two certificates will be present for each node. You must approve all of these certificates. After the client CSR is approved, the Kubelet creates a secondary CSR for the serving certificate, which requires manual approval. Then, subsequent serving certificate renewal requests are automatically approved by the **machine-approver** if the Kubelet requests a new certificate with identical parameters.

NOTE

For clusters running on platforms that are not machine API enabled, such as bare metal and other user-provisioned infrastructure, you must implement a method of automatically approving the kubelet serving certificate requests (CSRs). If a request is not approved, then the **oc exec**, **oc rsh**, and **oc logs** commands cannot succeed, because a serving certificate is required when the API server connects to the kubelet. Any operation that contacts the Kubelet endpoint requires this certificate approval to be in place. The method must watch for new CSRs, confirm that the CSR was submitted by the **node-bootstrapper** service account in the **system:node** or **system:admin** groups, and confirm the identity of the node.

- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

1 **<csr_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{{"\n"}}
{{end}}{{end}}' | xargs --no-run-if-empty oc adm certificate approve
```

NOTE

Some Operators might not become available until some CSRs are approved.

4. Now that your client requests are approved, you must review the server requests for each machine that you added to the cluster:

```
$ oc get csr
```

Example output

```
NAME        AGE     REQUESTOR                                                   CONDITION
csr-bfd72   5m26s   system:node:ip-10-0-50-126.us-east-2.compute.internal
Pending
csr-c57lv   5m26s   system:node:ip-10-0-95-157.us-east-2.compute.internal
Pending
...
```

5. If the remaining CSRs are not approved, and are in the **Pending** status, approve the CSRs for your cluster machines:

   - To approve them individually, run the following command for each valid CSR:

     ```
     $ oc adm certificate approve <csr_name> 1
     ```

     1 **<csr_name>** is the name of a CSR from the list of current CSRs.

   - To approve all pending CSRs, run the following command:

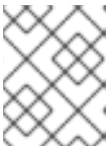
     ```
     $ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{{"\n"}}
     {{end}}{{end}}' | xargs oc adm certificate approve
     ```

6. After all client and server CSRs have been approved, the machines have the **Ready** status. Verify this by running the following command:

   ```
   $ oc get nodes
   ```

   Example output

   ```
   NAME      STATUS    ROLES   AGE  VERSION
   master-0  Ready     master  73m  v1.24.0
   master-1  Ready     master  73m  v1.24.0
   master-2  Ready     master  74m  v1.24.0
   worker-0  Ready     worker  11m  v1.24.0
   worker-1  Ready     worker  11m  v1.24.0
   ```

   NOTE

   It can take a few minutes after approval of the server CSRs for the machines to transition to the **Ready** status.

Additional information

- For more information on CSRs, see Certificate Signing Requests.

19.6.25. Verifying a successful installation

Verify that the OpenShift Container Platform installation is complete.

Prerequisites

- You have the installation program (**openshift-install**)

Procedure

- On a command line, enter:

  ```
  $ openshift-install --log-level debug wait-for install-complete
  ```

The program outputs the console URL, as well as the administrator's login information.

19.6.26. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.11, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to OpenShift Cluster Manager Hybrid Cloud Console.

After you confirm that your OpenShift Cluster Manager Hybrid Cloud Console inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, use subscription watch to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

Additional resources

- See About remote health monitoring for more information about the Telemetry service

19.6.27. Next steps

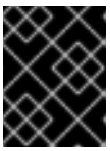
- Customize your cluster.
- If necessary, you can opt out of remote health reporting .
- If you need to enable external access to node ports, configure ingress cluster traffic by using a node port.
- If you did not configure RHOSP to accept application traffic over floating IP addresses, configure RHOSP access with floating IP addresses .

19.7. INSTALLING A CLUSTER ON OPENSTACK IN A RESTRICTED NETWORK

In OpenShift Container Platform 4.11, you can install a cluster on Red Hat OpenStack Platform (RHOSP) in a restricted network by creating an internal mirror of the installation release content.

19.7.1. Prerequisites

- You reviewed details about the OpenShift Container Platform installation and update processes.
- You read the documentation on selecting a cluster installation method and preparing it for users.
- You verified that OpenShift Container Platform 4.11 is compatible with your RHOSP version by using the Supported platforms for OpenShift clusters section. You can also compare platform support across different versions by viewing the OpenShift Container Platform on RHOSP support matrix.
- You created a registry on your mirror host and obtained the **imageContentSources** data for your version of OpenShift Container Platform.



IMPORTANT

Because the installation media is on the mirror host, you can use that computer to complete all installation steps.

- You understand performance and scalability practices for cluster scaling, control plane sizing, and etcd. For more information, see Recommended host practices.
- You have the metadata service enabled in RHOSP.

19.7.2. About installations in restricted networks

In OpenShift Container Platform 4.11, you can perform an installation that does not require an active connection to the internet to obtain software components. Restricted network installations can be completed using installer-provisioned infrastructure or user-provisioned infrastructure, depending on the cloud platform to which you are installing the cluster.

If you choose to perform a restricted network installation on a cloud platform, you still require access to its cloud APIs. Some cloud functions, like Amazon Web Service's Route 53 DNS and IAM services, require internet access. Depending on your network, you might require less internet access for an installation on bare metal hardware or on VMware vSphere.

To complete a restricted network installation, you must create a registry that mirrors the contents of the OpenShift image registry and contains the installation media. You can create this registry on a mirror host, which can access both the internet and your closed network, or by using other methods that meet your restrictions.

19.7.2.1. Additional limits

Clusters in restricted networks have the following additional limitations and restrictions:

- The **ClusterVersion** status includes an **Unable to retrieve available updates** error.
- By default, you cannot use the contents of the Developer Catalog because you cannot access the required image stream tags.

19.7.3. Resource guidelines for installing OpenShift Container Platform on RHOSP

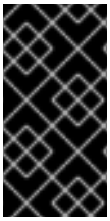
To support an OpenShift Container Platform installation, your Red Hat OpenStack Platform (RHOSP) quota must meet the following requirements:

Table 19.25. Recommended resources for a default OpenShift Container Platform cluster on RHOSP

Resource	Value
Floating IP addresses	3
Ports	15
Routers	1
Subnets	1
RAM	88 GB
vCPUs	22

Resource	Value
Volume storage	275 GB
Instances	7
Security groups	3
Security group rules	60
Server groups	2 - plus 1 for each additional availability zone in each machine pool

A cluster might function with fewer than recommended resources, but its performance is not guaranteed.



IMPORTANT

If RHOSP object storage (Swift) is available and operated by a user account with the **swiftoperator** role, it is used as the default backend for the OpenShift Container Platform image registry. In this case, the volume storage requirement is 175 GB. Swift space requirements vary depending on the size of the image registry.

NOTE

By default, your security group and security group rule quotas might be low. If you encounter problems, run **openstack quota set --secgroups 3 --secgroup-rules 60 <project>** as an administrator to increase them.

An OpenShift Container Platform deployment comprises control plane machines, compute machines, and a bootstrap machine.

19.7.3.1. Control plane machines

By default, the OpenShift Container Platform installation process creates three control plane machines.

Each machine requires:

- An instance from the RHOSP quota
- A port from the RHOSP quota
- A flavor with at least 16 GB memory and 4 vCPUs
- At least 100 GB storage space from the RHOSP quota

19.7.3.2. Compute machines

By default, the OpenShift Container Platform installation process creates three compute machines.

Each machine requires:

- An instance from the RHOSP quota
- A port from the RHOSP quota
- A flavor with at least 8 GB memory and 2 vCPUs
- At least 100 GB storage space from the RHOSP quota

TIP

Compute machines host the applications that you run on OpenShift Container Platform; aim to run as many as you can.

19.7.3.3. Bootstrap machine

During installation, a bootstrap machine is temporarily provisioned to stand up the control plane. After the production control plane is ready, the bootstrap machine is deprovisioned.

The bootstrap machine requires:

- An instance from the RHOSP quota
- A port from the RHOSP quota
- A flavor with at least 16 GB memory and 4 vCPUs
- At least 100 GB storage space from the RHOSP quota

19.7.4. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.11, you require access to the internet to obtain the images that are necessary to install your cluster.

You must have internet access to:

- Access OpenShift Cluster Manager Hybrid Cloud Console to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access Quay.io to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.

IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

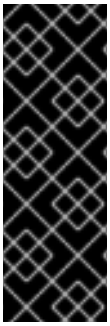
19.7.5. Enabling Swift on RHOSP

Swift is operated by a user account with the **swiftoperator** role. Add the role to an account before you run the installation program.

IMPORTANT

If the Red Hat OpenStack Platform (RHOSP) object storage service , commonly known as Swift, is available, OpenShift Container Platform uses it as the image registry storage. If it is unavailable, the installation program relies on the RHOSP block storage service, commonly known as Cinder.

If Swift is present and you want to use it, you must enable access to it. If it is not present, or if you do not want to use it, skip this section.



IMPORTANT

RHOSP 17 sets the **rgw_max_attr_size** parameter of Ceph RGW to 256 characters. This setting causes issues with uploading container images to the OpenShift Container Platform registry. You must set the value of **rgw_max_attr_size** to at least 1024 characters.

Before installation, check if your RHOSP deployment is affected by this problem. If it is, reconfigure Ceph RGW.

Prerequisites

- You have a RHOSP administrator account on the target environment.
- The Swift service is installed.
- On Ceph RGW, the **account in url** option is enabled.

Procedure

To enable Swift on RHOSP:

1. As an administrator in the RHOSP CLI, add the **swiftoperator** role to the account that will access Swift:

```
$ openstack role add --user <user> --project <project> swiftoperator
```

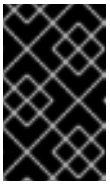
Your RHOSP deployment can now use Swift for the image registry.

19.7.6. Defining parameters for the installation program

The OpenShift Container Platform installation program relies on a file that is called **clouds.yaml**. The file describes Red Hat OpenStack Platform (RHOSP) configuration parameters, including the project name, log in information, and authorization service URLs.

Procedure

1. Create the **clouds.yaml** file:
   - If your RHOSP distribution includes the Horizon web UI, generate a **clouds.yaml** file in it.



IMPORTANT

Remember to add a password to the **auth** field. You can also keep secrets in a separate file from **clouds.yaml**. OpenShift Container Platform does not support application credentials.

- If your RHOSP distribution does not include the Horizon web UI, or you do not want to use Horizon, create the file yourself. For detailed information about **clouds.yaml**, see Config files in the RHOSP documentation.

```
clouds:
  shiftstack:
    auth:
      auth_url: http://10.10.14.42:5000/v3
      project_name: shiftstack
      username: <username>
      password: <password>
      user_domain_name: Default
      project_domain_name: Default
  dev-env:
    region_name: RegionOne
    auth:
      username: <username>
      password: <password>
      project_name: 'devonly'
      auth_url: 'https://10.10.14.22:5001/v2.0'
```

2. If your RHOSP installation uses self-signed certificate authority (CA) certificates for endpoint authentication:

   a. Copy the certificate authority file to your machine.

   b. Add the **cacerts** key to the **clouds.yaml** file. The value must be an absolute, non-root-accessible path to the CA certificate:

```
clouds:
  shiftstack:
    ...
    cacert: "/etc/pki/ca-trust/source/anchors/ca.crt.pem"
```

   TIP

   After you run the installer with a custom CA certificate, you can update the certificate by editing the value of the **ca-cert.pem** key in the **cloud-provider-config** keymap. On a command line, run:

```
$ oc edit configmap -n openshift-config cloud-provider-config
```

3. Place the **clouds.yaml** file in one of the following locations:

   a. The value of the **OS_CLIENT_CONFIG_FILE** environment variable

   b. The current directory

c. A Unix-specific user configuration directory, for example ~/**.config/openstack/clouds.yaml**

d. A Unix-specific site configuration directory, for example /**etc/openstack/clouds.yaml**
The installation program searches for **clouds.yaml** in that order.

19.7.7. Setting cloud provider options

Optionally, you can edit the cloud provider configuration for your cluster. The cloud provider configuration controls how OpenShift Container Platform interacts with Red Hat OpenStack Platform (RHOSP).

For a complete list of cloud provider configuration parameters, see the "OpenStack cloud configuration reference guide" page in the "Installing on OpenStack" documentation.

Procedure

1. If you have not already generated manifest files for your cluster, generate them by running the following command:

```
$ openshift-install --dir <destination_directory> create manifests
```

2. In a text editor, open the cloud-provider configuration manifest file. For example:

```
$ vi openshift/manifests/cloud-provider-config.yaml
```

3. Modify the options based on the cloud configuration specification.
Configuring Octavia for load balancing is a common case for clusters that do not use Kuryr. For example:

```
#...
[LoadBalancer]
use-octavia=true (1)
lb-provider = "amphora" (2)
floating-network-id="d3deb660-4190-40a3-91f1-37326fe6ec4a" (3)
create-monitor = True (4)
monitor-delay = 10s (5)
monitor-timeout = 10s (6)
monitor-max-retries = 1 (7)
#...
```

(1) This property enables Octavia integration.

(2) This property sets the Octavia provider that your load balancer uses. It accepts **"ovn"** or **"amphora"** as values. If you choose to use OVN, you must also set **lb-method** to **SOURCE_IP_PORT**.

(3) This property is required if you want to use multiple external networks with your cluster. The cloud provider creates floating IP addresses on the network that is specified here.

(4) This property controls whether the cloud provider creates health monitors for Octavia load balancers. Set the value to **True** to create health monitors. As of RHOSP 16.1 and 16.2, this feature is only available for the Amphora provider.

5 This property sets the frequency with which endpoints are monitored. The value must be in the **time.ParseDuration()** format. This property is required if the value of the **create-monitor** property is **True**.

6 This property sets the time that monitoring requests are open before timing out. The value must be in the **time.ParseDuration()** format. This property is required if the value of the **create-monitor** property is **True**.

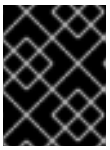
7 This property defines how many successful monitoring requests are required before a load balancer is marked as online. The value must be an integer. This property is required if the value of the **create-monitor** property is **True**.

IMPORTANT

Prior to saving your changes, verify that the file is structured correctly. Clusters might fail if properties are not placed in the appropriate section.

IMPORTANT

You must set the value of the **create-monitor** property to **True** if you use services that have the value of the **.spec.externalTrafficPolicy** property set to **Local**. The OVN Octavia provider in RHOSP 16.1 and 16.2 does not support health monitors. Therefore, services that have **ETP** parameter values set to **Local** might not respond when the **lb-provider** value is set to **"ovn"**.



IMPORTANT

For installations that use Kuryr, Kuryr handles relevant services. There is no need to configure Octavia load balancing in the cloud provider.

4. Save the changes to the file and proceed with installation.

TIP

You can update your cloud provider configuration after you run the installer. On a command line, run:

```
$ oc edit configmap -n openshift-config cloud-provider-config
```

After you save your changes, your cluster will take some time to reconfigure itself. The process is complete if none of your nodes have a **SchedulingDisabled** status.

19.7.7.1. External load balancers that use pre-defined floating IP addresses

Commonly, Red Hat OpenStack Platform (RHOSP) deployments disallow non-administrator users from creating specific floating IP addresses. If such a policy is in place and you use a floating IP address in your service specification, the cloud provider will fail to handle IP address assignment to load balancers.

If you use an external cloud provider, you can avoid this problem by pre-creating a floating IP address and specifying it in your service specification. The in-tree cloud provider does not support this method.

Alternatively, you can modify the RHOSP Networking service (Neutron) to allow non-administrator users to create specific floating IP addresses.

Additional resources

- For more information about cloud provider configuration, see OpenStack cloud provider options.

19.7.8. Creating the RHCOS image for restricted network installations

Download the Red Hat Enterprise Linux CoreOS (RHCOS) image to install OpenShift Container Platform on a restricted network Red Hat OpenStack Platform (RHOSP) environment.

Prerequisites

- Obtain the OpenShift Container Platform installation program. For a restricted network installation, the program is on your mirror registry host.

Procedure

1. Log in to the Red Hat Customer Portal's Product Downloads page.
2. Under **Version**, select the most recent release of OpenShift Container Platform 4.11 for RHEL 8.

IMPORTANT

The RHCOS images might not change with every release of OpenShift Container Platform. You must download images with the highest version that is less than or equal to the OpenShift Container Platform version that you install. Use the image versions that match your OpenShift Container Platform version if they are available.

3. Download the **Red Hat Enterprise Linux CoreOS (RHCOS) - OpenStack Image (QCOW)** image.
4. Decompress the image.

NOTE

You must decompress the image before the cluster can use it. The name of the downloaded file might not contain a compression extension, like **.gz** or **.tgz**. To find out if or how the file is compressed, in a command line, enter:

```
$ file <name_of_downloaded_file>
```

5. Upload the image that you decompressed to a location that is accessible from the bastion server, like Glance. For example:

```
$ openstack image create --file rhcos-44.81.202003110027-0-openstack.x86_64.qcow2 --
disk-format qcow2 rhcos-${RHCOS_VERSION}
```

IMPORTANT

Depending on your RHOSP environment, you might be able to upload the image in either **.raw** or **.qcow2** formats. If you use Ceph, you must use the **.raw** format.

WARNING

If the installation program finds multiple images with the same name, it chooses one of them at random. To avoid this behavior, create unique names for resources in RHOSP.

The image is now available for a restricted installation. Note the image name or location for use in OpenShift Container Platform deployment.

19.7.9. Creating the installation configuration file

You can customize the OpenShift Container Platform cluster you install on Red Hat OpenStack Platform (RHOSP).

Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster. For a restricted network installation, these files are on your mirror host.
- Have the **imageContentSources** values that were generated during mirror registry creation.
- Obtain the contents of the certificate for your mirror registry.
- Retrieve a Red Hat Enterprise Linux CoreOS (RHCOS) image and upload it to an accessible location.
- Obtain service principal permissions at the subscription level.

Procedure

1. Create the **install-config.yaml** file.
   a. Change to the directory that contains the installation program and run the following command:

```
$ ./openshift-install create install-config --dir <installation_directory> 1
```

1 For **<installation_directory>**, specify the directory name to store the files that the installation program creates.

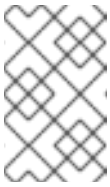
When specifying the directory:

- Verify that the directory has the **execute** permission. This permission is required to run Terraform binaries under the installation directory.
- Use an empty directory. Some installation assets, such as bootstrap X.509 certificates, have short expiration intervals, therefore you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them

into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

b. At the prompts, provide the configuration details for your cloud:

i. Optional: Select an SSH key to use to access your cluster machines.



NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

ii. Select **openstack** as the platform to target.

iii. Specify the Red Hat OpenStack Platform (RHOSP) external network name to use for installing the cluster.

iv. Specify the floating IP address to use for external access to the OpenShift API.

v. Specify a RHOSP flavor with at least 16 GB RAM to use for control plane nodes and 8 GB RAM for compute nodes.

vi. Select the base domain to deploy the cluster to. All DNS records will be sub-domains of this base and will also include the cluster name.

vii. Enter a name for your cluster. The name must be 14 or fewer characters long.

viii. Paste the pull secret from the Red Hat OpenShift Cluster Manager .

2. In the **install-config.yaml** file, set the value of **platform.openstack.clusterOSImage** to the image location or name. For example:

```
platform:
  openstack:
    clusterOSImage: http://mirror.example.com/images/rhcos-43.81.201912131630.0-
openstack.x86_64.qcow2.gz?
sha256=ffebbd68e8a1f2a245ca19522c16c86f67f9ac8e4e0c1f0a812b068b16f7265d
```

3. Edit the **install-config.yaml** file to give the additional information that is required for an installation in a restricted network.

a. Update the **pullSecret** value to contain the authentication information for your registry:

```
pullSecret: '{"auths":{"<mirror_host_name>:5000": {"auth": "<credentials>","email":
"you@example.com"}}}'
```

For **<mirror_host_name>**, specify the registry domain name that you specified in the certificate for your mirror registry, and for **<credentials>**, specify the base64-encoded user name and password for your mirror registry.

b. Add the **additionalTrustBundle** parameter and value.

```
additionalTrustBundle: |
  -----BEGIN CERTIFICATE-----
```

```
ZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZ
-----END CERTIFICATE-----
```

The value must be the contents of the certificate file that you used for your mirror registry. The certificate file can be an existing, trusted certificate authority, or the self-signed certificate that you generated for the mirror registry.

c. Add the image content resources, which resemble the following YAML excerpt:

```
imageContentSources:
- mirrors:
  - <mirror_host_name>:5000/<repo_name>/release
  source: quay.io/openshift-release-dev/ocp-release
- mirrors:
  - <mirror_host_name>:5000/<repo_name>/release
  source: registry.redhat.io/ocp/release
```

For these values, use the **imageContentSources** that you recorded during mirror registry creation.

4. Make any other modifications to the **install-config.yaml** file that you require. You can find more information about the available parameters in the **Installation configuration parameters** section.

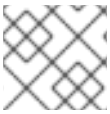
5. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.

IMPORTANT

The **install-config.yaml** file is consumed during the installation process. If you want to reuse the file, you must back it up now.

19.7.9.1. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.



NOTE

Kuryr installations default to HTTP proxies.

Prerequisites

- For Kuryr installations on restricted networks that use the **Proxy** object, the proxy must be able to reply to the router that the cluster uses. To add a static route for the proxy configuration, from a command line as the root user, enter:

```
$ ip route add <cluster_network_cidr> via <installer_subnet_gateway>
```

- The restricted subnet must have a gateway that is defined and available to be linked to the **Router** resource that Kuryr creates.

- You have an existing **install-config.yaml** file.

- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.

NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

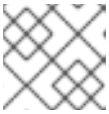
For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
```

1. A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
2. A proxy URL to use for creating HTTPS connections outside the cluster.
3. A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use ***** to bypass the proxy for all destinations.
4. If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace that contains one or more additional CA certificates that are required for proxying HTTPS connections. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges these contents with the Red Hat Enterprise Linux CoreOS (RHCOS) trust bundle, and this config map is referenced in the **trustedCA** field of the **Proxy** object. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.



NOTE

The installation program does not support the proxy **readinessEndpoints** field.

NOTE

If the installer times out, restart and then complete the deployment by using the **wait-for** command of the installer. For example:

```
$ ./openshift-install wait-for install-complete --log-level debug
```

2. Save the file and reference it when installing OpenShift Container Platform.

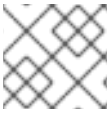
The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.

NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

19.7.9.2. Installation configuration parameters

Before you deploy an OpenShift Container Platform cluster, you provide parameter values to describe your account on the cloud platform that hosts your cluster and optionally customize your cluster's platform. When you create the **install-config.yaml** installation configuration file, you provide values for the required parameters through the command line. If you customize your cluster, you can modify the **install-config.yaml** file to provide more details about the platform.



NOTE

After installation, you cannot modify these parameters in the **install-config.yaml** file.

19.7.9.2.1. Required configuration parameters

Required installation configuration parameters are described in the following table:

Table 19.26. Required parameters

Parameter	Description	Values
apiVersion	The API version for the **install-config.yaml** content. The current version is **v1**. The installer may also support older API versions.	String

Parameter	Description	Values
baseDomain	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the **baseDomain** and **metadata.name** parameter values that uses the **<metadata.name>.<baseDomain>** format.	A fully-qualified domain or subdomain name, such as **example.com**.
metadata	Kubernetes resource **ObjectMeta**, from which only the **name** parameter is consumed.	Object
metadata.name	The name of the cluster. DNS records for the cluster are all subdomains of **{{.metadata.name}}.{{.baseDomain}}**.	String of lowercase letters, hyphens (**-**), and periods (**.**), such as **dev**. The string must be 14 characters or fewer long.
platform	The configuration for the specific platform upon which to perform the installation: **alibabacloud**, **aws**, **baremetal**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**. For additional information about **platform.<platform>** parameters, consult the table for your specific platform that follows.	Object

Parameter	Description	Values
pullSecret	Get a pull secret from the Red Hat OpenShift Cluster Manager to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	<pre>{ "auths":{ "cloud.openshift.com":{ "auth":"b3Blb=", "email":"you@example.com" }, "quay.io":{ "auth":"b3Blb=", "email":"you@example.com" } } }</pre>

19.7.9.2.2. Network configuration parameters

You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

Only IPv4 addresses are supported.

NOTE

Globalnet is not supported with Red Hat OpenShift Data Foundation disaster recovery solutions. For regional disaster recovery scenarios, ensure that you use a nonoverlapping range of private IP addresses for the cluster and service networks in each cluster.

Table 19.27. Network parameters

Parameter	Description	Values
networking	The configuration for the cluster network.	Object  **NOTE** You cannot modify parameters specified by the **networking** object after installation.

Parameter	Description	Values
networking.networkType	The cluster network provider Container Network Interface (CNI) cluster network provider to install.	Either **OpenShiftSDN** or **OVNKubernetes**. **OpenShiftSDN** is a CNI provider for all-Linux networks. **OVNKubernetes** is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is **OpenShiftSDN**.
networking.clusterNetwork	The IP address blocks for pods. The default value is **10.128.0.0/14** with a host prefix of **/23**. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: `networking:` `  clusterNetwork:` `  - cidr: 10.128.0.0/14` `  hostPrefix: 23`
networking.clusterNetwork.cidr	Required if you use **networking.clusterNetwork**. An IP address block. An IPv4 network.	An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between **0** and **32**.
networking.clusterNetwork.hostPrefix	The subnet prefix length to assign to each individual node. For example, if **hostPrefix** is set to **23** then each node is assigned a **/23** subnet out of the given **cidr**. A **hostPrefix** value of **23** provides 510 (2^(32 - 23) - 2) pod IP addresses.	A subnet prefix. The default value is **23**.
networking.serviceNetwork	The IP address block for services. The default value is **172.30.0.0/16**. The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.	An array with an IP address block in CIDR format. For example: `networking:` `  serviceNetwork:` `  - 172.30.0.0/16`
networking.machineNetwork	The IP address blocks for machines. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: `networking:` `  machineNetwork:` `  - cidr: 10.0.0.0/16`

Parameter	Description	Values
networking.machineNetwork.cidr	Required if you use **networking.machineNetwork**. An IP address block. The default value is **10.0.0.0/16** for all platforms other than libvirt. For libvirt, the default value is **192.168.126.0/24**.	An IP network block in CIDR notation. For example, **10.0.0.0/16**.  **NOTE** Set the **networking.machineNetwork** to match the CIDR that the preferred NIC resides in.

19.7.9.2.3. Optional configuration parameters

Optional installation configuration parameters are described in the following table:

Table 19.28. Optional parameters

Parameter	Description	Values
additionalTrustBundle	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String
capabilities	Controls the installation of optional core cluster components. You can reduce the footprint of your OpenShift Container Platform cluster by disabling optional components.	String array
capabilities.baselineCapabilitySet	Selects an initial set of optional capabilities to enable. Valid values are **None**, **v4.11** and **vCurrent**. **v4.11** enables the **baremetal** Operator, the **marketplace** Operator, and the **openshift-samples** content. **vCurrent** installs the recommended set of capabilities for the current version of OpenShift Container Platform. The default value is **vCurrent**.	String

Parameter	Description	Values
capabilities.additionalEnabledCapabilities	Extends the set of optional capabilities beyond what you specify in **baselineCapabilitySet**. Valid values are **baremetal**, **marketplace** and **openshift-samples**. You may specify multiple capabilities in this parameter.	String array
cgroupsV2	Enables Linux control groups version 2 (cgroups v2) on specific nodes in your cluster. The OpenShift Container Platform process for enabling cgroups v2 disables all cgroup version 1 controllers and hierarchies. The OpenShift Container Platform cgroups version 2 feature is in Developer Preview and is not supported by Red Hat at this time.	**true**
compute	The configuration for the machines that comprise the compute nodes.	Array of **MachinePool** objects.
compute.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** (the default).	String
compute.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  IMPORTANT If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
compute.name	Required if you use **compute**. The name of the machine pool.	**worker**

Parameter	Description	Values
compute.platform	Required if you use **compute**. Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the **controlPlane.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
compute.replicas	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to **2**. The default value is **3**.
controlPlane	The configuration for the machines that comprise the control plane.	Array of **MachinePool** objects.
controlPlane.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** (the default).	String
controlPlane.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  IMPORTANT If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
controlPlane.name	Required if you use **controlPlane**. The name of the machine pool.	**master**

Parameter	Description	Values
controlPlane.platform	Required if you use **controlPlane**. Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the **compute.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
controlPlane.replicas	The number of control plane machines to provision.	The only supported value is **3**, which is the default value.
credentialsMode	The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported.  **NOTE** Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the *Cloud Credential Operator* entry in the *Cluster Operators reference* content.  **NOTE** If your AWS account has service control policies (SCP) enabled, you must configure the **credentialsMode** parameter to **Mint**, **Passthrough** or **Manual**.	**Mint**, **Passthrough**, **Manual** or an empty string (**""**).

Parameter	Description	Values
fips	Enable or disable FIPS mode. The default is **false** (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.  **IMPORTANT** To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.  **NOTE** If you are using Azure File storage, you cannot enable FIPS mode.	**false** or **true**
imageContentSources	Sources and repositories for the release-image content.	Array of objects. Includes a **source** and, optionally, **mirrors**, as described in the following rows of this table.
imageContentSources.source	Required if you use **imageContentSources**. Specify the repository that users refer to, for example, in image pull specifications.	String

Parameter	Description	Values
imageContentSources.mirrors	Specify one or more repositories that may also contain the same images.	Array of strings
publish	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	**Internal** or **External**. The default value is **External**. Setting this field to **Internal** is not supported on non-cloud platforms and IBM Cloud VPC.  **IMPORTANT** If the value of the field is set to **Internal**, the cluster will become non-functional. For more information, refer to BZ#1953035.
sshKey	The SSH key to authenticate access to your cluster machines.  **NOTE** For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.	For example, **sshKey: ssh-ed25519 AAAA..**.

19.7.9.2.4. Additional Red Hat OpenStack Platform (RHOSP) configuration parameters

Additional RHOSP configuration parameters are described in the following table:

Table 19.29. Additional RHOSP parameters

Parameter	Description	Values
compute.platform.openstack.rootVolume.size	For compute machines, the size in gigabytes of the root volume. If you do not set this value, machines use ephemeral storage.	Integer, for example **30**.

Parameter	Description	Values
compute.platform.openstack.rootVolume.type	For compute machines, the root volume's type.	String, for example **performance**.
controlPlane.platform.openstack.rootVolume.size	For control plane machines, the size in gigabytes of the root volume. If you do not set this value, machines use ephemeral storage.	Integer, for example **30**.
controlPlane.platform.openstack.rootVolume.type	For control plane machines, the root volume's type.	String, for example **performance**.
platform.openstack.cloud	The name of the RHOSP cloud to use from the list of clouds in the **clouds.yaml** file.	String, for example **MyCloud**.
platform.openstack.externalNetwork	The RHOSP external network name to be used for installation.	String, for example **external**.
platform.openstack.computeFlavor	The RHOSP flavor to use for control plane and compute machines. This property is deprecated. To use a flavor as the default for all machine pools, add it as the value of the **type** key in the **platform.openstack.defaultMachinePlatform** property. You can also set a flavor value for each machine pool individually.	String, for example **m1.xlarge**.

19.7.9.2.5. Optional RHOSP configuration parameters

Optional RHOSP configuration parameters are described in the following table:

Table 19.30. Optional RHOSP parameters

Parameter	Description	Values
compute.platform.openstack.additionalNetworkIDs	Additional networks that are associated with compute machines. Allowed address pairs are not created for additional networks.	A list of one or more UUIDs as strings. For example, **fa806b2f-ac49-4bce-b9db-124bc64209bf**.
compute.platform.openstack.additionalSecurityGroupIDs	Additional security groups that are associated with compute machines.	A list of one or more UUIDs as strings. For example, **7ee219f3-d2e9-48a1-96c2-e7429f1b0da7**.
compute.platform.openstack.zones	RHOSP Compute (Nova) availability zones (AZs) to install machines on. If this parameter is not set, the installer relies on the default settings for Nova that the RHOSP administrator configured. On clusters that use Kuryr, RHOSP Octavia does not support availability zones. Load balancers and, if you are using the Amphora provider driver, OpenShift Container Platform services that rely on Amphora VMs, are not created according to the value of this property.	A list of strings. For example, **["zone-1", "zone-2"]**.
compute.platform.openstack.rootVolume.zones	For compute machines, the availability zone to install root volumes on. If you do not set a value for this parameter, the installer selects the default availability zone.	A list of strings, for example **["zone-1", "zone-2"]**.

Parameter	Description	Values
compute.platform.openstack.serverGroupPolicy	Server group policy to apply to the group that will contain the compute machines in the pool. You cannot change server group policies or affiliations after creation. Supported options include **anti-affinity**, **soft-affinity**, and **soft-anti-affinity**. The default value is **soft-anti-affinity**. An **affinity** policy prevents migrations and therefore affects RHOSP upgrades. The **affinity** policy is not supported. If you use a strict **anti-affinity** policy, an additional RHOSP host is required during instance migration.	A server group policy to apply to the machine pool. For example, **soft-affinity**.
controlPlane.platform.openstack.additionalNetworkIDs	Additional networks that are associated with control plane machines. Allowed address pairs are not created for additional networks.	A list of one or more UUIDs as strings. For example, **fa806b2f-ac49-4bce-b9db-124bc64209bf**.
controlPlane.platform.openstack.additionalSecurityGroupIDs	Additional security groups that are associated with control plane machines.	A list of one or more UUIDs as strings. For example, **7ee219f3-d2e9-48a1-96c2-e7429f1b0da7**.

Parameter	Description	Values
controlPlane.platform.openstack.zones	RHOSP Compute (Nova) availability zones (AZs) to install machines on. If this parameter is not set, the installer relies on the default settings for Nova that the RHOSP administrator configured. On clusters that use Kuryr, RHOSP Octavia does not support availability zones. Load balancers and, if you are using the Amphora provider driver, OpenShift Container Platform services that rely on Amphora VMs, are not created according to the value of this property.	A list of strings. For example, **["zone-1", "zone-2"]**.
controlPlane.platform.openstack.rootVolume.zones	For control plane machines, the availability zone to install root volumes on. If you do not set this value, the installer selects the default availability zone.	A list of strings, for example **["zone-1", "zone-2"]**.
controlPlane.platform.openstack.serverGroupPolicy	Server group policy to apply to the group that will contain the control plane machines in the pool. You cannot change server group policies or affiliations after creation. Supported options include **anti-affinity**, **soft-affinity**, and **soft-anti-affinity**. The default value is **soft-anti-affinity**. An **affinity** policy prevents migrations, and therefore affects RHOSP upgrades. The **affinity** policy is not supported. If you use a strict **anti-affinity** policy, an additional RHOSP host is required during instance migration.	A server group policy to apply to the machine pool. For example, **soft-affinity**.

Parameter	Description	Values
platform.openstack.clusterOSImage	The location from which the installer downloads the RHCOS image. You must set this parameter to perform an installation in a restricted network.	An HTTP or HTTPS URL, optionally with an SHA-256 checksum. For example, **http://mirror.example.com/images/rhcos-43.81.201912131630.0-openstack.x86_64.qcow2.gz?sha256=ffebbd68e8a1f2a245ca19522c16c86f67f9ac8e4e0c1f0a812b068b16f7265d**. The value can also be the name of an existing Glance image, for example **my-rhcos**.
platform.openstack.clusterOSImageProperties	Properties to add to the installer-uploaded ClusterOSImage in Glance. This property is ignored if **platform.openstack.clusterOSImage** is set to an existing Glance image. You can use this property to exceed the default persistent volume (PV) limit for RHOSP of 26 PVs per node. To exceed the limit, set the **hw_scsi_model** property value to **virtio-scsi** and the **hw_disk_bus** value to **scsi**. You can also use this property to enable the QEMU guest agent by including the **hw_qemu_guest_agent** property with a value of **yes**.	A list of key-value string pairs. For example, **["hw_scsi_model": "virtio-scsi", "hw_disk_bus": "scsi"]**.
platform.openstack.defaultMachinePlatform	The default machine pool platform configuration.	<pre>{ "type": "ml.large", "rootVolume": { "size": 30, "type": "performance" } }</pre>
platform.openstack.ingressFloatingIP	An existing floating IP address to associate with the Ingress port. To use this property, you must also define the **platform.openstack.externalNetwork** property.	An IP address, for example **128.0.0.1**.

Parameter	Description	Values
platform.openstack.apiFloatingIP	An existing floating IP address to associate with the API load balancer. To use this property, you must also define the **platform.openstack.externalNetwork** property.	An IP address, for example **128.0.0.1**.
platform.openstack.externalDNS	IP addresses for external DNS servers that cluster instances use for DNS resolution.	A list of IP addresses as strings. For example, **["8.8.8.8", "192.168.1.12"]**.
platform.openstack.machinesSubnet	The UUID of a RHOSP subnet that the cluster's nodes use. Nodes and virtual IP (VIP) ports are created on this subnet. The first item in **networking.machineNetwork** must match the value of **machinesSubnet**. If you deploy to a custom subnet, you cannot specify an external DNS server to the OpenShift Container Platform installer. Instead, add DNS to the subnet in RHOSP.	A UUID as a string. For example, **fa806b2f-ac49-4bce-b9db-124bc64209bf**.

19.7.9.3. Sample customized install-config.yaml file for restricted OpenStack installations

This sample **install-config.yaml** demonstrates all of the possible Red Hat OpenStack Platform (RHOSP) customization options.

IMPORTANT

This sample file is provided for reference only. You must obtain your **install-config.yaml** file by using the installation program.

```
apiVersion: v1
baseDomain: example.com
controlPlane:
  name: master
  platform: {}
  replicas: 3
compute:
- name: worker
  platform:
    openstack:
      type: ml.large
```

```
  replicas: 3
metadata:
  name: example
networking:
  clusterNetwork:
  - cidr: 10.128.0.0/14
    hostPrefix: 23
  machineNetwork:
  - cidr: 10.0.0.0/16
  serviceNetwork:
  - 172.30.0.0/16
  networkType: OpenShiftSDN
platform:
  openstack:
    region: region1
    cloud: mycloud
    externalNetwork: external
    computeFlavor: m1.xlarge
    apiFloatingIP: 128.0.0.1
fips: false
pullSecret: '{"auths": ...}'
sshKey: ssh-ed25519 AAAA...
additionalTrustBundle: |

  -----BEGIN CERTIFICATE-----

  ZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZ

  -----END CERTIFICATE-----

imageContentSources:
- mirrors:
  - <mirror_registry>/<repo_name>/release
  source: quay.io/openshift-release-dev/ocp-release
- mirrors:
  - <mirror_registry>/<repo_name>/release
  source: quay.io/openshift-release-dev/ocp-v4.0-art-dev
```

19.7.10. Generating a key pair for cluster node SSH access

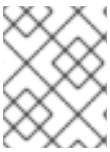
During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the **~/.ssh/authorized_keys** list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The **./openshift-install gather** command also requires the SSH public key to be in place on the cluster nodes.

IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.



NOTE

You must use a local key, not one that you configured with platform-specific approaches such as AWS key pairs.

Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N '' -f <path>/<file_name> 1
```

1 Specify the path and file name, such as **~/.ssh/id_ed25519**, of the new SSH key. If you have an existing key pair, ensure your public key is in the your **~/.ssh** directory.

NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS validated or Modules In Process cryptographic libraries on the **x86_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

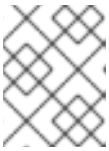
2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the **~/.ssh/id_ed25519.pub** public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the **./openshift-install gather** command.



NOTE

On some distributions, default SSH private key identities such as **~/.ssh/id_rsa** and **~/.ssh/id_dsa** are managed automatically.

a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

Example output

```
Agent pid 31874
```

NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

1 Specify the path and file name for your SSH private key, such as **~/.ssh/id_ed25519**

Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

19.7.11. Enabling access to the environment

At deployment, all OpenShift Container Platform machines are created in a Red Hat OpenStack Platform (RHOSP)-tenant network. Therefore, they are not accessible directly in most RHOSP deployments.

You can configure OpenShift Container Platform API and application access by using floating IP addresses (FIPs) during installation. You can also complete an installation without configuring FIPs, but the installer will not configure a way to reach the API or applications externally.

19.7.11.1. Enabling access with floating IP addresses

Create floating IP (FIP) addresses for external access to the OpenShift Container Platform API and cluster applications.

Procedure

1. Using the Red Hat OpenStack Platform (RHOSP) CLI, create the API FIP:

```
$ openstack floating ip create --description "API <cluster_name>.<base_domain>"
<external_network>
```

2. Using the Red Hat OpenStack Platform (RHOSP) CLI, create the apps, or Ingress, FIP:

```
$ openstack floating ip create --description "Ingress <cluster_name>.<base_domain>"
<external_network>
```

3. Add records that follow these patterns to your DNS server for the API and Ingress FIPs:

```
api.<cluster_name>.<base_domain>.  IN  A  <API_FIP>
*.apps.<cluster_name>.<base_domain>. IN  A <apps_FIP>
```

NOTE

If you do not control the DNS server, you can access the cluster by adding the cluster domain names such as the following to your **/etc/hosts** file:

- **<api_floating_ip> api.<cluster_name>.<base_domain>**
- **<application_floating_ip> grafana-openshift-monitoring.apps.<cluster_name>.<base_domain>**
- **<application_floating_ip> prometheus-k8s-openshift-monitoring.apps.<cluster_name>.<base_domain>**
- **<application_floating_ip> oauth-openshift.apps.<cluster_name>.<base_domain>**
- **<application_floating_ip> console-openshift-console.apps.<cluster_name>.<base_domain>**
- **application_floating_ip integrated-oauth-server-openshift-authentication.apps.<cluster_name>.<base_domain>**

The cluster domain names in the **/etc/hosts** file grant access to the web console and the monitoring interface of your cluster locally. You can also use the **kubectl** or **oc**. You can access the user applications by using the additional entries pointing to the <application_floating_ip>. This action makes the API and applications accessible to only you, which is not suitable for production deployment, but does allow installation for development and testing.

4. Add the FIPs to the **install-config.yaml** file as the values of the following parameters:
   - **platform.openstack.ingressFloatingIP**
   - **platform.openstack.apiFloatingIP**

If you use these values, you must also enter an external network as the value of the **platform.openstack.externalNetwork** parameter in the **install-config.yaml** file.

TIP

You can make OpenShift Container Platform resources available outside of the cluster by assigning a floating IP address and updating your firewall configuration.

19.7.11.2. Completing installation without floating IP addresses

You can install OpenShift Container Platform on Red Hat OpenStack Platform (RHOSP) without providing floating IP addresses.

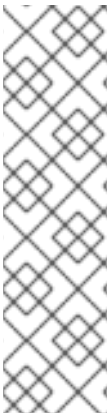
In the **install-config.yaml** file, do not define the following parameters:

- **platform.openstack.ingressFloatingIP**

- **platform.openstack.apiFloatingIP**

If you cannot provide an external network, you can also leave **platform.openstack.externalNetwork** blank. If you do not provide a value for **platform.openstack.externalNetwork**, a router is not created for you, and, without additional action, the installer will fail to retrieve an image from Glance. You must configure external connectivity on your own.

If you run the installer from a system that cannot reach the cluster API due to a lack of floating IP addresses or name resolution, installation fails. To prevent installation failure in these cases, you can use a proxy network or run the installer from a system that is on the same network as your machines.



NOTE

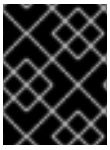
You can enable name resolution by creating DNS records for the API and Ingress ports. For example:

```
api.<cluster_name>.<base_domain>.  IN  A  <api_port_IP>
*.apps.<cluster_name>.<base_domain>. IN  A <ingress_port_IP>
```

If you do not control the DNS server, you can add the record to your **/etc/hosts** file. This action makes the API accessible to only you, which is not suitable for production deployment but does allow installation for development and testing.

19.7.12. Deploying the cluster

You can install OpenShift Container Platform on a compatible cloud platform.



IMPORTANT

You can run the **create cluster** command of the installation program only once, during initial installation.

Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.

Procedure

- Change to the directory that contains the installation program and initialize the cluster deployment:

```
$ ./openshift-install create cluster --dir <installation_directory> \ 1
    --log-level=info 2
```

1 For **<installation_directory>**, specify the location of your customized **./install-config.yaml** file.

2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

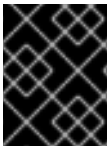
NOTE

If the cloud provider account that you configured on your host does not have sufficient permissions to deploy the cluster, the installation process stops, and the missing permissions are displayed.

Verification

When the cluster deployment completes successfully:

- The terminal displays directions for accessing your cluster, including a link to the web console and credentials for the **kubeadmin** user.
- Credential information also outputs to **<installation_directory>/.openshift_install.log**.

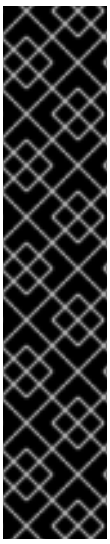


IMPORTANT

Do not delete the installation program or the files that the installation program creates. Both are required to delete the cluster.

Example output

```
...
INFO Install complete!
INFO To access the cluster as the system:admin user when using 'oc', run 'export
KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
INFO Access the OpenShift web-console here: https://console-openshift-
console.apps.mycluster.example.com
INFO Login to the console with user: "kubeadmin", and password: "password"
INFO Time elapsed: 36m22s
```



IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

19.7.13. Verifying cluster status

You can verify your OpenShift Container Platform cluster's status during or after installation.

Procedure

1. In the cluster environment, export the administrator's kubeconfig file:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server.

2. View the control plane and compute machines created after a deployment:

```
$ oc get nodes
```

3. View your cluster's version:

```
$ oc get clusterversion
```

4. View your Operators' status:

```
$ oc get clusteroperator
```

5. View all running pods in the cluster:

```
$ oc get pods -A
```

19.7.14. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

Example output

```
system:admin
```

Additional resources

- See Accessing the web console for more details about accessing and understanding the OpenShift Container Platform web console.

19.7.15. Disabling the default OperatorHub sources

Operator catalogs that source content provided by Red Hat and community projects are configured for OperatorHub by default during an OpenShift Container Platform installation. In a restricted network environment, you must disable the default catalogs as a cluster administrator.

Procedure

- Disable the sources for the default catalogs by adding **disableAllDefaultSources: true** to the **OperatorHub** object:

```
$ oc patch OperatorHub cluster --type json \
    -p '[{"op": "add", "path": "/spec/disableAllDefaultSources", "value": true}]'
```

TIP

Alternatively, you can use the web console to manage catalog sources. From the **Administration → Cluster Settings → Configuration → OperatorHub** page, click the **Sources** tab, where you can create, update, delete, disable, and enable individual sources.

19.7.16. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.11, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to OpenShift Cluster Manager Hybrid Cloud Console.

After you confirm that your OpenShift Cluster Manager Hybrid Cloud Console inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, use subscription watch to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

Additional resources

- See About remote health monitoring for more information about the Telemetry service

19.7.17. Next steps

- Customize your cluster.
- If the mirror registry that you used to install your cluster has a trusted CA, add it to the cluster by configuring additional trust stores.
- If necessary, you can opt out of remote health reporting .
- If necessary, see Registering your disconnected cluster

- Configure image streams for the Cluster Samples Operator and the **must-gather** tool.
- Learn how to use Operator Lifecycle Manager (OLM) on restricted networks .
- If you did not configure RHOSP to accept application traffic over floating IP addresses, configure RHOSP access with floating IP addresses .

19.8. OPENSTACK CLOUD CONFIGURATION REFERENCE GUIDE

A cloud provider configuration controls how OpenShift Container Platform interacts with Red Hat OpenStack Platform (RHOSP). Use the following parameters in a cloud-provider configuration manifest file to configure your cluster.

19.8.1. OpenStack cloud provider options

The cloud provider configuration, typically stored as a file named **cloud.conf**, controls how OpenShift Container Platform interacts with Red Hat OpenStack Platform (RHOSP).

You can create a valid **cloud.conf** file by specifying the following options in it.

19.8.1.1. Global options

The following options are used for RHOSP CCM authentication with the RHOSP Identity service, also known as Keystone. They are similiar to the global options that you can set by using the **openstack** CLI.

Option	Description
auth-url	The RHOSP Identity service URL. For example, **http://128.110.154.166/identity**.
ca-file	Optional. The CA certificate bundle file for communication with the RHOSP Identity service. If you use the HTTPS protocol with The Identity service URL, this option is required.
domain-id	The Identity service user domain ID. Leave this option unset if you are using Identity service application credentials.
domain-name	The Identity service user domain name. This option is not required if you set **domain-id**.
tenant-id	The Identity service project ID. Leave this option unset if you are using Identity service application credentials. In version 3 of the Identity API, which changed the identifier **tenant** to **project**, the value of **tenant-id** is automatically mapped to the project construct in the API.

Option	Description
tenant-name	The Identity service project name.
username	The Identity service user name. Leave this option unset if you are using Identity service application credentials.
password	The Identity service user password. Leave this option unset if you are using Identity service application credentials.
region	The Identity service region name.
trust-id	The Identity service trust ID. A trust represents the authorization of a user, or trustor, to delegate roles to another user, or trustee. Optionally, a trust authorizes the trustee to impersonate the trustor. You can find available trusts by querying the **/v3/OS-TRUST/trusts** endpoint of the Identity service API.

19.8.1.2. Load balancer options

The cloud provider supports several load balancer options for deployments that use Octavia.

Option	Description
use-octavia	Whether or not to use Octavia for the **LoadBalancer** type of the service implementation rather than Neutron-LBaaS. The default value is **true**.
floating-network-id	Optional. The external network used to create floating IP addresses for load balancer virtual IP addresses (VIPs). If there are multiple external networks in the cloud, this option must be set or the user must specify **loadbalancer.openstack.org/floating-network-id** in the service annotation.

Option	Description
lb-method	The load balancing algorithm used to create the load balancer pool. For the Amphora provider the value can be **ROUND_ROBIN**, **LEAST_CONNECTIONS**, or **SOURCE_IP**. The default value is **ROUND_ROBIN**. For the OVN provider, only the **SOURCE_IP_PORT** algorithm is supported. For the Amphora provider, if using the **LEAST_CONNECTIONS** or **SOURCE_IP** methods, configure the **create-monitor** option as **true** in the **cloud-provider-config** config map on the **openshift-config** namespace and **ETP:Local** on the load-balancer type service to allow balancing algorithm enforcement in the client to service endpoint connections.
lb-provider	Optional. Used to specify the provider of the load balancer, for example, **amphora** or **octavia**. Only the Amphora and Octavia providers are supported.
lb-version	Optional. The load balancer API version. Only **"v2"** is supported.
subnet-id	The ID of the Networking service subnet on which load balancer VIPs are created.
create-monitor	Whether or not to create a health monitor for the service load balancer. A health monitor is required for services that declare **externalTrafficPolicy: Local**. The default value is **false**. This option is unsupported if you use RHOSP earlier than version 17 with the **ovn** provider.
monitor-delay	The interval in seconds by which probes are sent to members of the load balancer. The default value is **5**.
monitor-max-retries	The number of successful checks that are required to change the operating status of a load balancer member to **ONLINE**. The valid range is **1** to **10**, and the default value is **1**.
monitor-timeout	The time in seconds that a monitor waits to connect to the back end before it times out. The default value is **3**.

19.8.1.3. Metadata options

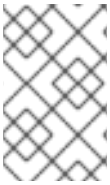
Option	Description
search-order	This configuration key affects the way that the provider retrieves metadata that relates to the instances in which it runs. The default value of **configDrive,metadataService** results in the provider retrieving instance metadata from the configuration drive first if available, and then the metadata service. Alternative values are: • **configDrive**: Only retrieve instance metadata from the configuration drive. • **metadataService**: Only retrieve instance metadata from the metadata service. • **metadataService,configDrive**: Retrieve instance metadata from the metadata service first if available, and then retrieve instance metadata from the configuration drive.

19.9. UNINSTALLING A CLUSTER ON OPENSTACK

You can remove a cluster that you deployed to Red Hat OpenStack Platform (RHOSP).

19.9.1. Removing a cluster that uses installer-provisioned infrastructure

You can remove a cluster that uses installer-provisioned infrastructure from your cloud.



NOTE

After uninstallation, check your cloud provider for any resources not removed properly, especially with User Provisioned Infrastructure (UPI) clusters. There might be resources that the installer did not create or that the installer is unable to access.

Prerequisites

- You have a copy of the installation program that you used to deploy the cluster.
- You have the files that the installation program generated when you created your cluster.

Procedure

1. On the computer that you used to install the cluster, go to the directory that contains the installation program, and run the following command:

```
$ ./openshift-install destroy cluster \
--dir <installation_directory> --log-level info 1 2
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2 To view different details, specify **warn**, **debug**, or **error** instead of **info**.

NOTE

You must specify the directory that contains the cluster definition files for your cluster. The installation program requires the **metadata.json** file in this directory to delete the cluster.

2. Optional: Delete the **<installation_directory>** directory and the OpenShift Container Platform installation program.

19.10. UNINSTALLING A CLUSTER ON RHOSP FROM YOUR OWN INFRASTRUCTURE

You can remove a cluster that you deployed to Red Hat OpenStack Platform (RHOSP) on user-provisioned infrastructure.

19.10.1. Downloading playbook dependencies

The Ansible playbooks that simplify the removal process on user-provisioned infrastructure require several Python modules. On the machine where you will run the process, add the modules' repositories and then download them.

NOTE

These instructions assume that you are using Red Hat Enterprise Linux (RHEL) 8.

Prerequisites

- Python 3 is installed on your machine.

Procedure

1. On a command line, add the repositories:
   a. Register with Red Hat Subscription Manager:

```
$ sudo subscription-manager register # If not done already
```

   b. Pull the latest subscription data:

```
$ sudo subscription-manager attach --pool=$YOUR_POOLID # If not done already
```

   c. Disable the current repositories:

```
$ sudo subscription-manager repos --disable=* # If not done already
```

   d. Add the required repositories:

```
$ sudo subscription-manager repos \
  --enable=rhel-8-for-x86_64-baseos-rpms \
```

```
--enable=openstack-16-tools-for-rhel-8-x86_64-rpms \
--enable=ansible-2.9-for-rhel-8-x86_64-rpms \
--enable=rhel-8-for-x86_64-appstream-rpms
```

2. Install the modules:

```
$ sudo yum install python3-openstackclient ansible python3-openstacksdk
```

3. Ensure that the **python** command points to **python3**:

```
$ sudo alternatives --set python /usr/bin/python3
```

19.10.2. Removing a cluster from RHOSP that uses your own infrastructure

You can remove an OpenShift Container Platform cluster on Red Hat OpenStack Platform (RHOSP) that uses your own infrastructure. To complete the removal process quickly, run several Ansible playbooks.

Prerequisites

- Python 3 is installed on your machine.
- You downloaded the modules in "Downloading playbook dependencies."
- You have the playbooks that you used to install the cluster.
- You modified the playbooks that are prefixed with **down-** to reflect any changes that you made to their corresponding installation playbooks. For example, changes to the **bootstrap.yaml** file are reflected in the **down-bootstrap.yaml** file.
- All of the playbooks are in a common directory.

Procedure

1. On a command line, run the playbooks that you downloaded:

```
$ ansible-playbook -i inventory.yaml  \
 down-bootstrap.yaml      \
 down-control-plane.yaml  \
 down-compute-nodes.yaml  \
 down-load-balancers.yaml \
 down-network.yaml        \
 down-security-groups.yaml
```

2. Remove any DNS record changes you made for the OpenShift Container Platform installation.

OpenShift Container Platform is removed from your infrastructure.

CHAPTER 20. INSTALLING ON RHV

20.1. PREPARING TO INSTALL ON RED HAT VIRTUALIZATION (RHV)

20.1.1. Prerequisites

- You reviewed details about the OpenShift Container Platform installation and update processes.
- You have a supported combination of versions in the Support Matrix for OpenShift Container Platform on Red Hat Virtualization (RHV).
- You read the documentation on selecting a cluster installation method and preparing it for users.

20.1.2. Choosing a method to install OpenShift Container Platform on RHV

You can install OpenShift Container Platform on installer-provisioned or user-provisioned infrastructure. The default installation type uses installer-provisioned infrastructure, where the installation program provisions the underlying infrastructure for the cluster. You can also install OpenShift Container Platform on infrastructure that you provision. If you do not use infrastructure that the installation program provisions, you must manage and maintain the cluster resources yourself.

See Installation process for more information about installer-provisioned and user-provisioned installation processes.

20.1.2.1. Installing a cluster on installer-provisioned infrastructure

You can install a cluster on Red Hat Virtualization (RHV) virtual machines that are provisioned by the OpenShift Container Platform installation program, by using one of the following methods:

- **Installing a cluster quickly on RHV**: You can quickly install OpenShift Container Platform on RHV virtual machines that the OpenShift Container Platform installation program provisions.
- **Installing a cluster on RHV with customizations**: You can install a customized OpenShift Container Platform cluster on installer-provisioned guests on RHV. The installation program allows for some customization to be applied at the installation stage. Many other customization options are available post-installation.

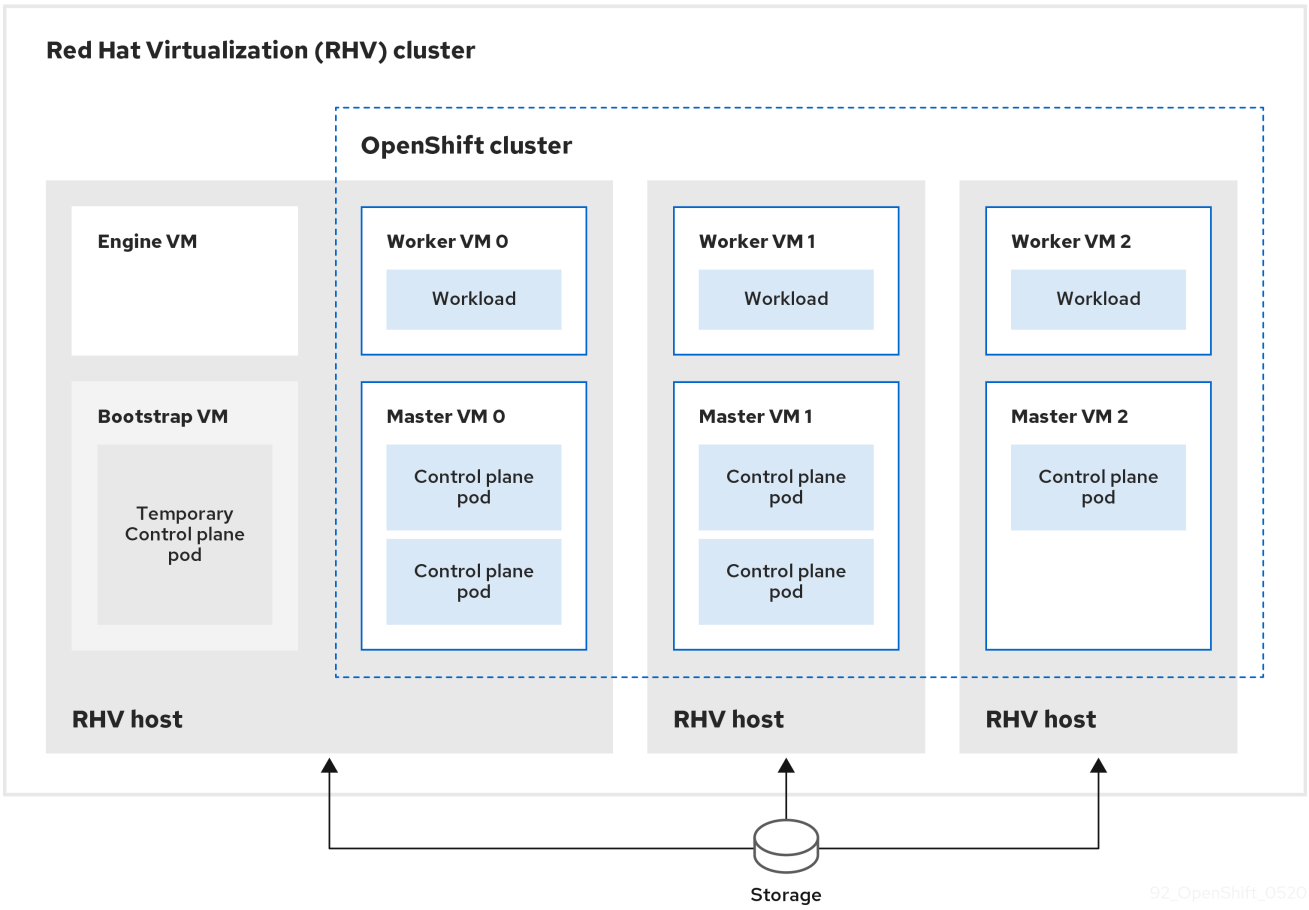
20.1.2.2. Installing a cluster on user-provisioned infrastructure

You can install a cluster on RHV virtual machines that you provision, by using one of the following methods:

- **Installing a cluster on RHV with user-provisioned infrastructure**: You can install OpenShift Container Platform on RHV virtual machines that you provision. You can use the provided Ansible playbooks to assist with the installation.
- **Installing a cluster on RHV in a restricted network**: You can install OpenShift Container Platform on RHV in a restricted or disconnected network by creating an internal mirror of the installation release content. You can use this method to install a user-provisioned cluster that does not require an active internet connection to obtain the software components. You can also use this installation method to ensure that your clusters only use container images that satisfy your organizational controls on external content.

20.2. INSTALLING A CLUSTER QUICKLY ON RHV

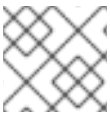
You can quickly install a default, non-customized, OpenShift Container Platform cluster on a Red Hat Virtualization (RHV) cluster, similar to the one shown in the following diagram.



The installation program uses installer-provisioned infrastructure to automate creating and deploying the cluster.

To install a default cluster, you prepare the environment, run the installation program and answer its prompts. Then, the installation program creates the OpenShift Container Platform cluster.

For an alternative to installing a default cluster, see Installing a cluster with customizations .



NOTE

This installation program is available for Linux and macOS only.

20.2.1. Prerequisites

- You reviewed details about the OpenShift Container Platform installation and update processes.
- You have a supported combination of versions in the Support Matrix for OpenShift Container Platform on Red Hat Virtualization (RHV).
- You read the documentation on selecting a cluster installation method and preparing it for users.

- If you use a firewall, you configured it to allow the sites that your cluster requires access to.

20.2.2. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.11, you require access to the internet to install your cluster.

You must have internet access to:

- Access OpenShift Cluster Manager Hybrid Cloud Console to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access Quay.io to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.

IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

20.2.3. Requirements for the RHV environment

To install and run an OpenShift Container Platform version 4.11 cluster, the RHV environment must meet the following requirements.

Not meeting these requirements can cause the installation or process to fail. Additionally, not meeting these requirements can cause the OpenShift Container Platform cluster to fail days or weeks after installation.

The following requirements for CPU, memory, and storage resources are based on **default** values multiplied by the default number of virtual machines the installation program creates. These resources must be available **in addition to** what the RHV environment uses for non-OpenShift Container Platform operations.

By default, the installation program creates seven virtual machines during the installation process. First, it creates a bootstrap virtual machine to provide temporary services and a control plane while it creates the rest of the OpenShift Container Platform cluster. When the installation program finishes creating the cluster, deleting the bootstrap machine frees up its resources.

If you increase the number of virtual machines in the RHV environment, you must increase the resources accordingly.

Requirements

- The RHV version is 4.4.
- The RHV environment has one data center whose state is **Up**.
- The RHV data center contains an RHV cluster.

- The RHV cluster has the following resources exclusively for the OpenShift Container Platform cluster:
    - Minimum 28 vCPUs: four for each of the seven virtual machines created during installation.
    - 112 GiB RAM or more, including:
        - 16 GiB or more for the bootstrap machine, which provides the temporary control plane.
        - 16 GiB or more for each of the three control plane machines which provide the control plane.
        - 16 GiB or more for each of the three compute machines, which run the application workloads.
- The RHV storage domain must meet these etcd backend performance requirements.
- For affinity group support: Three or more hosts in the RHV cluster. If necessary, you can disable affinity groups. For details, see *Example: Removing all affinity groups for a non-production lab setup* in *Installing a cluster on RHV with customizations*
- In production environments, each virtual machine must have 120 GiB or more. Therefore, the storage domain must provide 840 GiB or more for the default OpenShift Container Platform cluster. In resource-constrained or non-production environments, each virtual machine must have 32 GiB or more, so the storage domain must have 230 GiB or more for the default OpenShift Container Platform cluster.
- To download images from the Red Hat Ecosystem Catalog during installation and update procedures, the RHV cluster must have access to an internet connection. The Telemetry service also needs an internet connection to simplify the subscription and entitlement process.
- The RHV cluster must have a virtual network with access to the REST API on the RHV Manager. Ensure that DHCP is enabled on this network, because the VMs that the installer creates obtain their IP address by using DHCP.
- A user account and group with the following least privileges for installing and managing an OpenShift Container Platform cluster on the target RHV cluster:
    - **DiskOperator**
    - **DiskCreator**
    - **UserTemplateBasedVm**
    - **TemplateOwner**
    - **TemplateCreator**
    - **ClusterAdmin** on the target cluster

WARNING

Apply the principle of least privilege: Avoid using an administrator account with **SuperUser** privileges on RHV during the installation process. The installation program saves the credentials you provide to a temporary **ovirt-config.yaml** file that might be compromised.

Additional resources

- Example: Removing all affinity groups for a non-production lab setup .

20.2.4. Verifying the requirements for the RHV environment

Verify that the RHV environment meets the requirements to install and run an OpenShift Container Platform cluster. Not meeting these requirements can cause failures.

IMPORTANT

These requirements are based on the default resources the installation program uses to create control plane and compute machines. These resources include vCPUs, memory, and storage. If you change these resources or increase the number of OpenShift Container Platform machines, adjust these requirements accordingly.

Procedure

1. Check that the RHV version supports installation of OpenShift Container Platform version 4.11.
   a. In the RHV Administration Portal, click the **?** help icon in the upper-right corner and select **About**.
   b. In the window that opens, make a note of the **RHV Software Version**.
   c. Confirm that the RHV version is 4.4. For more information about supported version combinations, see Support Matrix for OpenShift Container Platform on RHV .
2. Inspect the data center, cluster, and storage.
   a. In the RHV Administration Portal, click **Compute → Data Centers**.
   b. Confirm that the data center where you plan to install OpenShift Container Platform is accessible.
   c. Click the name of that data center.
   d. In the data center details, on the **Storage** tab, confirm the storage domain where you plan to install OpenShift Container Platform is **Active**.
   e. Record the **Domain Name** for use later on.
   f. Confirm **Free Space** has at least 230 GiB.

g. Confirm that the storage domain meets these etcd backend performance requirements, which you can measure by using the fio performance benchmarking tool .

h. In the data center details, click the **Clusters** tab.

i. Find the RHV cluster where you plan to install OpenShift Container Platform. Record the cluster name for use later on.

3. Inspect the RHV host resources.

a. In the RHV Administration Portal, click **Compute** > **Clusters**.

b. Click the cluster where you plan to install OpenShift Container Platform.

c. In the cluster details, click the **Hosts** tab.

d. Inspect the hosts and confirm they have a combined total of at least 28 **Logical CPU Cores** available *exclusively* for the OpenShift Container Platform cluster.

e. Record the number of available **Logical CPU Cores** for use later on.

f. Confirm that these CPU cores are distributed so that each of the seven virtual machines created during installation can have four cores.

g. Confirm that, all together, the hosts have 112 GiB of **Max free Memory for scheduling new virtual machines** distributed to meet the requirements for each of the following OpenShift Container Platform machines:

- 16 GiB required for the bootstrap machine
- 16 GiB required for each of the three control plane machines
- 16 GiB for each of the three compute machines

h. Record the amount of **Max free Memory for scheduling new virtual machines** for use later on.

4. Verify that the virtual network for installing OpenShift Container Platform has access to the RHV Manager's REST API. From a virtual machine on this network, use curl to reach the RHV Manager's REST API:

```
$ curl -k -u <username>@<profile>:<password> \ 1
https://<engine-fqdn>/ovirt-engine/api 2
```

1 For **<username>**, specify the user name of an RHV account with privileges to create and manage an OpenShift Container Platform cluster on RHV. For **<profile>**, specify the login profile, which you can get by going to the RHV Administration Portal login page and reviewing the **Profile** dropdown list. For **<password>**, specify the password for that user name.

2 For **<engine-fqdn>**, specify the fully qualified domain name of the RHV environment.

For example:

```
$ curl -k -u ocpadmin@internal:pw123 \
https://rhv-env.virtlab.example.com/ovirt-engine/api
```

20.2.5. Preparing the network environment on RHV

Configure two static IP addresses for the OpenShift Container Platform cluster and create DNS entries using these addresses.

Procedure

1. Reserve two static IP addresses

   a. On the network where you plan to install OpenShift Container Platform, identify two static IP addresses that are outside the DHCP lease pool.

   b. Connect to a host on this network and verify that each of the IP addresses is not in use. For example, use Address Resolution Protocol (ARP) to check that none of the IP addresses have entries:

   ```
   $ arp 10.35.1.19
   ```

   Example output

   ```
   10.35.1.19 (10.35.1.19) -- no entry
   ```

   c. Reserve two static IP addresses following the standard practices for your network environment.

   d. Record these IP addresses for future reference.

2. Create DNS entries for the OpenShift Container Platform REST API and apps domain names using this format:

   ```
   api.<cluster-name>.<base-domain>   <ip-address> 1
   *.apps.<cluster-name>.<base-domain>   <ip-address> 2
   ```

   1 For **<cluster-name>**, **<base-domain>**, and **<ip-address>**, specify the cluster name, base domain, and static IP address of your OpenShift Container Platform API.

   2 Specify the cluster name, base domain, and static IP address of your OpenShift Container Platform apps for Ingress and the load balancer.

   For example:

   ```
   api.my-cluster.virtlab.example.com 10.35.1.19
   *.apps.my-cluster.virtlab.example.com 10.35.1.20
   ```

20.2.6. Installing OpenShift Container Platform on RHV in insecure mode

By default, the installer creates a CA certificate, prompts you for confirmation, and stores the certificate to use during installation. You do not need to create or install one manually.

Although it is not recommended, you can override this functionality and install OpenShift Container Platform without verifying a certificate by installing OpenShift Container Platform on RHV in **insecure** mode.

WARNING

Installing in **insecure** mode is not recommended, because it enables a potential attacker to perform a Man-in-the-Middle attack and capture sensitive credentials on the network.

Procedure

1. Create a file named **~/.ovirt/ovirt-config.yaml**.
2. Add the following content to **ovirt-config.yaml**:

```
ovirt_url: https://ovirt.example.com/ovirt-engine/api (1)
ovirt_fqdn: ovirt.example.com (2)
ovirt_pem_url: ""
ovirt_username: ocpadmin@internal
ovirt_password: super-secret-password (3)
ovirt_insecure: true
```

(1) Specify the hostname or address of your oVirt engine.

(2) Specify the fully qualified domain name of your oVirt engine.

(3) Specify the admin password for your oVirt engine.

3. Run the installer.

20.2.7. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the **~/.ssh/authorized_keys** list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The **./openshift-install gather** command also requires the SSH public key to be in place on the cluster nodes.

IMPORTANT

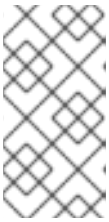
Do not skip this procedure in production environments, where disaster recovery and debugging is required.

Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N '' -f <path>/<file_name> 1
```

1 Specify the path and file name, such as ~/**.ssh/id_ed25519**, of the new SSH key. If you have an existing key pair, ensure your public key is in the your ~/**.ssh** directory.



NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS validated or Modules In Process cryptographic libraries on the **x86_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the ~/**.ssh/id_ed25519.pub** public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the **./openshift-install gather** command.

NOTE

On some distributions, default SSH private key identities such as ~/**.ssh/id_rsa** and ~/**.ssh/id_dsa** are managed automatically.

a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

Example output

```
Agent pid 31874
```

NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

1 Specify the path and file name for your SSH private key, such as **~/.ssh/id_ed25519**

Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

20.2.8. Obtaining the installation program

Before you install OpenShift Container Platform, download the installation file on a local computer.

Prerequisites

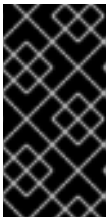
- You have a computer that runs Linux or macOS, with 500 MB of local disk space.

Procedure

1. Access the Infrastructure Provider page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program that corresponds with your host operating system and architecture, and place the file in the directory where you will store the installation configuration files.

IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.



IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation pull secret from the Red Hat OpenShift Cluster Manager . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform

components.

20.2.9. Deploying the cluster

You can install OpenShift Container Platform on a compatible cloud platform.

IMPORTANT

You can run the **create cluster** command of the installation program only once, during initial installation.

Prerequisites

- Open the **ovirt-imageio** port to the Manager from the machine running the installer. By default, the port is **54322**.
- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.

Procedure

1. Change to the directory that contains the installation program and initialize the cluster deployment:

```
$ ./openshift-install create cluster --dir <installation_directory> \ 1
    --log-level=info 2
```

1 For **<installation_directory>**, specify the directory name to store the files that the installation program creates.

2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

When specifying the directory:

- Verify that the directory has the **execute** permission. This permission is required to run Terraform binaries under the installation directory.
- Use an empty directory. Some installation assets, such as bootstrap X.509 certificates, have short expiration intervals, therefore you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

2. Respond to the installation program prompts.

   a. Optional: For **SSH Public Key**, select a password-less public key, such as **~/.ssh/id_rsa.pub**. This key authenticates connections with the new OpenShift Container Platform cluster.

NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, select an SSH key that your **ssh-agent** process uses.

b. For **Platform**, select **ovirt**.

c. For **Engine FQDN[:PORT]**, enter the fully qualified domain name (FQDN) of the RHV environment.
For example:

```
rhv-env.virtlab.example.com:443
```

d. The installer automatically generates a CA certificate. For **Would you like to use the above certificate to connect to the Manager?**, answer **y** or **N**. If you answer **N**, you must install OpenShift Container Platform in insecure mode.

e. For **Engine username**, enter the user name and profile of the RHV administrator using this format:

```
<username>@<profile> 1
```

1 For **<username>**, specify the user name of an RHV administrator. For **<profile>**, specify the login profile, which you can get by going to the RHV Administration Portal login page and reviewing the **Profile** dropdown list. For example: **admin@internal**.

f. For **Engine password**, enter the RHV admin password.

g. For **Cluster**, select the RHV cluster for installing OpenShift Container Platform.

h. For **Storage domain**, select the storage domain for installing OpenShift Container Platform.

i. For **Network**, select a virtual network that has access to the RHV Manager REST API.

j. For **Internal API Virtual IP**, enter the static IP address you set aside for the cluster's REST API.

k. For **Ingress virtual IP**, enter the static IP address you reserved for the wildcard apps domain.

l. For **Base Domain**, enter the base domain of the OpenShift Container Platform cluster. If this cluster is exposed to the outside world, this must be a valid domain recognized by DNS infrastructure. For example, enter: **virtlab.example.com**

m. For **Cluster Name**, enter the name of the cluster. For example, **my-cluster**. Use cluster name from the externally registered/resolvable DNS entries you created for the OpenShift Container Platform REST API and apps domain names. The installation program also gives this name to the cluster in the RHV environment.

n. For **Pull Secret**, copy the pull secret from the **pull-secret.txt** file you downloaded earlier and paste it here. You can also get a copy of the same pull secret from the Red Hat OpenShift Cluster Manager.

NOTE

If the cloud provider account that you configured on your host does not have sufficient permissions to deploy the cluster, the installation process stops, and the missing permissions are displayed.

Verification

When the cluster deployment completes successfully:

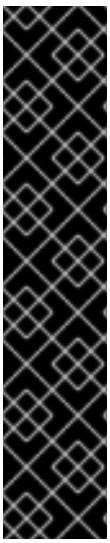
- The terminal displays directions for accessing your cluster, including a link to the web console and credentials for the **kubeadmin** user.
- Credential information also outputs to **<installation_directory>/.openshift_install.log**.

IMPORTANT

Do not delete the installation program or the files that the installation program creates. Both are required to delete the cluster.

Example output

```
...
INFO Install complete!
INFO To access the cluster as the system:admin user when using 'oc', run 'export
KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
INFO Access the OpenShift web-console here: https://console-openshift-
console.apps.mycluster.example.com
INFO Login to the console with user: "kubeadmin", and password: "password"
INFO Time elapsed: 36m22s
```



IMPORTANT

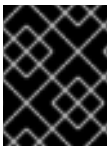
- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

IMPORTANT

You have completed the steps required to install the cluster. The remaining steps show you how to verify the cluster and troubleshoot the installation.

20.2.10. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.



IMPORTANT

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.11. Download and install the new version of **oc**.

Installing the OpenShift CLI on Linux

You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the architecture in the **Product Variant** drop-down menu.
3. Select the appropriate version in the **Version** drop-down menu.
4. Click **Download Now** next to the **OpenShift v4.11 Linux Client** entry and save the file.
5. Unpack the archive:

```
$ tar xvf <file>
```

6. Place the **oc** binary in a directory that is on your **PATH**.
   To check your **PATH**, execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.
   To check your **PATH**, open the command prompt and execute the following command:

```
```

```
C:\> path
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
C:\> oc <command>
```

Installing the OpenShift CLI on macOS
You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 macOS Client** entry and save the file.

NOTE

For macOS arm64, choose the **OpenShift v4.11 macOS arm64 Client** entry.

4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your PATH.
   To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

To learn more, see Getting started with the OpenShift CLI.

20.2.11. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

Procedure

Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

Example output

```
system:admin
```

Additional resources

- See Accessing the web console for more details about accessing and understanding the OpenShift Container Platform web console.

20.2.12. Verifying cluster status

You can verify your OpenShift Container Platform cluster's status during or after installation.

Procedure

1. In the cluster environment, export the administrator's kubeconfig file:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server.

2. View the control plane and compute machines created after a deployment:

```
$ oc get nodes
```

3. View your cluster's version:

```
$ oc get clusterversion
```

4. View your Operators' status:

```
$ oc get clusteroperator
```

5. View all running pods in the cluster:

```
$ oc get pods -A
```

Troubleshooting

If the installation fails, the installation program times out and displays an error message. To learn more, see Troubleshooting installation issues.

20.2.13. Accessing the OpenShift Container Platform web console on RHV

After the OpenShift Container Platform cluster initializes, you can log in to the OpenShift Container Platform web console.

Procedure

1. Optional: In the Red Hat Virtualization (RHV) Administration Portal, open **Compute → Cluster**.
2. Verify that the installation program creates the virtual machines.
3. Return to the command line where the installation program is running. When the installation program finishes, it displays the user name and temporary password for logging into the OpenShift Container Platform web console.
4. In a browser, open the URL of the OpenShift Container Platform web console. The URL uses this format:

```
console-openshift-console.apps.<clustername>.<basedomain> 1
```

1 For **<clustername>.<basedomain>**, specify the cluster name and base domain.

For example:

```
console-openshift-console.apps.my-cluster.virtlab.example.com
```

20.2.14. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.11, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to OpenShift Cluster Manager Hybrid Cloud Console.

After you confirm that your OpenShift Cluster Manager Hybrid Cloud Console inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, use subscription watch to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

Additional resources

- See About remote health monitoring for more information about the Telemetry service

20.2.15. Troubleshooting common issues with installing on Red Hat Virtualization (RHV)

Here are some common issues you might encounter, along with proposed causes and solutions.

20.2.15.1. CPU load increases and nodes go into a Not Ready state

- **Symptom**: CPU load increases significantly and nodes start going into a **Not Ready** state.
- **Cause**: The storage domain latency might be too high, especially for control plane nodes.
- **Solution**:
  Make the nodes ready again by restarting the kubelet service:

  ```
  $ systemctl restart kubelet
  ```

  Inspect the OpenShift Container Platform metrics service, which automatically gathers and reports on some valuable data such as the etcd disk sync duration. If the cluster is operational, use this data to help determine whether storage latency or throughput is the root issue. If so, consider using a storage resource that has lower latency and higher throughput.

  To get raw metrics, enter the following command as kubeadmin or user with cluster-admin privileges:

  ```
  $ oc get --insecure-skip-tls-verify --server=https://localhost:<port> --raw=/metrics
  ```

  To learn more, see Exploring Application Endpoints for the purposes of Debugging with OpenShift 4.x

20.2.15.2. Trouble connecting the OpenShift Container Platform cluster API

- **Symptom**: The installation program completes but the OpenShift Container Platform cluster API is not available. The bootstrap virtual machine remains up after the bootstrap process is complete. When you enter the following command, the response will time out.

  ```
  $ oc login -u kubeadmin -p *** <apiurl>
  ```

- **Cause**: The bootstrap VM was not deleted by the installation program and has not released the cluster's API IP address.
- **Solution**: Use the **wait-for** subcommand to be notified when the bootstrap process is complete:

  ```
  $ ./openshift-install wait-for bootstrap-complete
  ```

  When the bootstrap process is complete, delete the bootstrap virtual machine:

  ```
  $ ./openshift-install destroy bootstrap
  ```

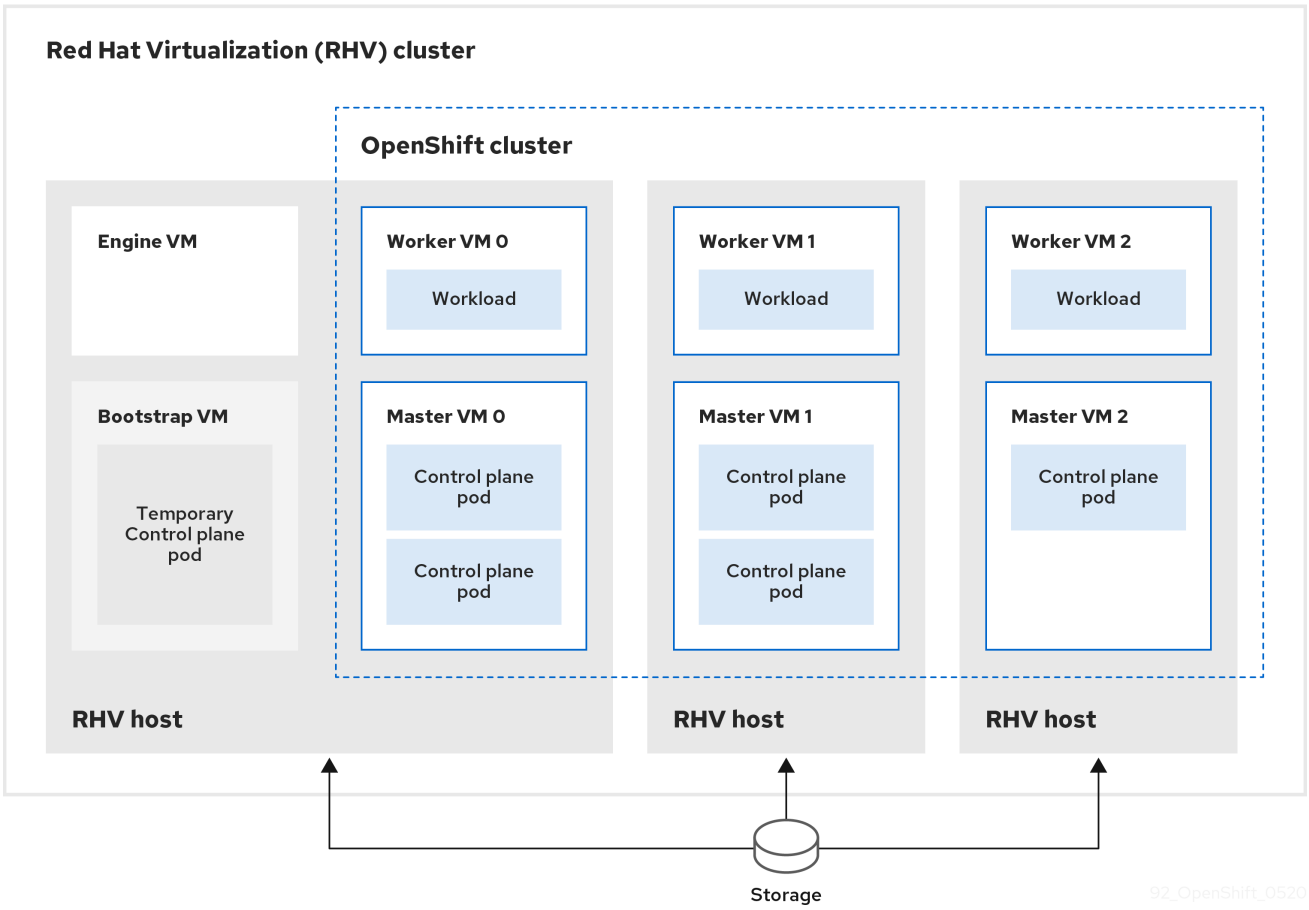
20.2.16. Post-installation tasks

After the OpenShift Container Platform cluster initializes, you can perform the following tasks.

- Optional: After deployment, add or replace SSH keys using the Machine Config Operator (MCO) in OpenShift Container Platform.
- Optional: Remove the **kubeadmin** user. Instead, use the authentication provider to create a user with cluster-admin privileges.

20.3. INSTALLING A CLUSTER ON RHV WITH CUSTOMIZATIONS

You can customize and install an OpenShift Container Platform cluster on Red Hat Virtualization (RHV), similar to the one shown in the following diagram.



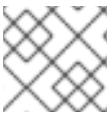
The installation program uses installer-provisioned infrastructure to automate creating and deploying the cluster.

To install a customized cluster, you prepare the environment and perform the following steps:

1. Create an installation configuration file, the **install-config.yaml** file, by running the installation program and answering its prompts.
2. Inspect and modify parameters in the **install-config.yaml** file.
3. Make a working copy of the **install-config.yaml** file.
4. Run the installation program with a copy of the **install-config.yaml** file.

Then, the installation program creates the OpenShift Container Platform cluster.

For an alternative to installing a customized cluster, see Installing a default cluster .



NOTE

This installation program is available for Linux and macOS only.

20.3.1. Prerequisites

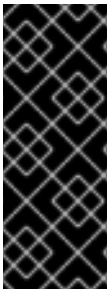
- You reviewed details about the OpenShift Container Platform installation and update processes.
- You have a supported combination of versions in the Support Matrix for OpenShift Container Platform on Red Hat Virtualization (RHV).
- You read the documentation on selecting a cluster installation method and preparing it for users.
- If you use a firewall, you configured it to allow the sites that your cluster requires access to.

20.3.2. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.11, you require access to the internet to install your cluster.

You must have internet access to:

- Access OpenShift Cluster Manager Hybrid Cloud Console to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access Quay.io to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.



IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

20.3.3. Requirements for the RHV environment

To install and run an OpenShift Container Platform version 4.11 cluster, the RHV environment must meet the following requirements.

Not meeting these requirements can cause the installation or process to fail. Additionally, not meeting these requirements can cause the OpenShift Container Platform cluster to fail days or weeks after installation.

The following requirements for CPU, memory, and storage resources are based on **default** values multiplied by the default number of virtual machines the installation program creates. These resources must be available **in addition to** what the RHV environment uses for non-OpenShift Container Platform operations.

By default, the installation program creates seven virtual machines during the installation process. First, it creates a bootstrap virtual machine to provide temporary services and a control plane while it creates the rest of the OpenShift Container Platform cluster. When the installation program finishes creating the cluster, deleting the bootstrap machine frees up its resources.

If you increase the number of virtual machines in the RHV environment, you must increase the resources accordingly.

Requirements

- The RHV version is 4.4.
- The RHV environment has one data center whose state is **Up**.
- The RHV data center contains an RHV cluster.
- The RHV cluster has the following resources exclusively for the OpenShift Container Platform cluster:
  - Minimum 28 vCPUs: four for each of the seven virtual machines created during installation.
  - 112 GiB RAM or more, including:
    - 16 GiB or more for the bootstrap machine, which provides the temporary control plane.
    - 16 GiB or more for each of the three control plane machines which provide the control plane.
    - 16 GiB or more for each of the three compute machines, which run the application workloads.
- The RHV storage domain must meet these etcd backend performance requirements.
- For affinity group support:
  One physical machine per worker or control plane. Workers and control planes can be on the same physical machine. For example, if you have three workers and three control planes, you need three physical machines. If you have four workers and three control planes, you need four physical machines.
  - For hard anti-affinity (default): A minimum of three physical machines. For more than three worker nodes, one physical machine per worker or control plane. Workers and control planes can be on the same physical machine.
  - For custom affinity groups: Ensure that the resources are appropriate for the affinity group rules that you define.
- In production environments, each virtual machine must have 120 GiB or more. Therefore, the storage domain must provide 840 GiB or more for the default OpenShift Container Platform cluster. In resource-constrained or non-production environments, each virtual machine must have 32 GiB or more, so the storage domain must have 230 GiB or more for the default OpenShift Container Platform cluster.
- To download images from the Red Hat Ecosystem Catalog during installation and update procedures, the RHV cluster must have access to an internet connection. The Telemetry service also needs an internet connection to simplify the subscription and entitlement process.
- The RHV cluster must have a virtual network with access to the REST API on the RHV Manager. Ensure that DHCP is enabled on this network, because the VMs that the installer creates obtain their IP address by using DHCP.
- A user account and group with the following least privileges for installing and managing an OpenShift Container Platform cluster on the target RHV cluster:
  - **DiskOperator**
  - **DiskCreator**

- **UserTemplateBasedVm**
- **TemplateOwner**
- **TemplateCreator**
- **ClusterAdmin** on the target cluster

WARNING

Apply the principle of least privilege: Avoid using an administrator account with **SuperUser** privileges on RHV during the installation process. The installation program saves the credentials you provide to a temporary **ovirt-config.yaml** file that might be compromised.

20.3.4. Verifying the requirements for the RHV environment

Verify that the RHV environment meets the requirements to install and run an OpenShift Container Platform cluster. Not meeting these requirements can cause failures.

IMPORTANT

These requirements are based on the default resources the installation program uses to create control plane and compute machines. These resources include vCPUs, memory, and storage. If you change these resources or increase the number of OpenShift Container Platform machines, adjust these requirements accordingly.

Procedure

1. Check that the RHV version supports installation of OpenShift Container Platform version 4.11.
   a. In the RHV Administration Portal, click the **?** help icon in the upper-right corner and select **About**.
   b. In the window that opens, make a note of the **RHV Software Version**
   c. Confirm that the RHV version is 4.4. For more information about supported version combinations, see Support Matrix for OpenShift Container Platform on RHV .
2. Inspect the data center, cluster, and storage.
   a. In the RHV Administration Portal, click **Compute → Data Centers**.
   b. Confirm that the data center where you plan to install OpenShift Container Platform is accessible.
   c. Click the name of that data center.
   d. In the data center details, on the **Storage** tab, confirm the storage domain where you plan to install OpenShift Container Platform is **Active**.

e. Record the **Domain Name** for use later on.

f. Confirm **Free Space** has at least 230 GiB.

g. Confirm that the storage domain meets these etcd backend performance requirements, which you can measure by using the fio performance benchmarking tool .

h. In the data center details, click the **Clusters** tab.

i. Find the RHV cluster where you plan to install OpenShift Container Platform. Record the cluster name for use later on.

3. Inspect the RHV host resources.

a. In the RHV Administration Portal, click **Compute > Clusters**.

b. Click the cluster where you plan to install OpenShift Container Platform.

c. In the cluster details, click the **Hosts** tab.

d. Inspect the hosts and confirm they have a combined total of at least 28 **Logical CPU Cores** available *exclusively* for the OpenShift Container Platform cluster.

e. Record the number of available **Logical CPU Cores** for use later on.

f. Confirm that these CPU cores are distributed so that each of the seven virtual machines created during installation can have four cores.

g. Confirm that, all together, the hosts have 112 GiB of **Max free Memory for scheduling new virtual machines** distributed to meet the requirements for each of the following OpenShift Container Platform machines:

- 16 GiB required for the bootstrap machine
- 16 GiB required for each of the three control plane machines
- 16 GiB for each of the three compute machines

h. Record the amount of **Max free Memory for scheduling new virtual machines** for use later on.

4. Verify that the virtual network for installing OpenShift Container Platform has access to the RHV Manager's REST API. From a virtual machine on this network, use curl to reach the RHV Manager's REST API:

```
$ curl -k -u <username>@<profile>:<password> \ 1
https://<engine-fqdn>/ovirt-engine/api 2
```

1 For **<username>**, specify the user name of an RHV account with privileges to create and manage an OpenShift Container Platform cluster on RHV. For **<profile>**, specify the login profile, which you can get by going to the RHV Administration Portal login page and reviewing the **Profile** dropdown list. For **<password>**, specify the password for that user name.

2 For **<engine-fqdn>**, specify the fully qualified domain name of the RHV environment.

For example:

```
$ curl -k -u ocpadmin@internal:pw123 \
https://rhv-env.virtlab.example.com/ovirt-engine/api
```

20.3.5. Preparing the network environment on RHV

Configure two static IP addresses for the OpenShift Container Platform cluster and create DNS entries using these addresses.

Procedure

1. Reserve two static IP addresses

   a. On the network where you plan to install OpenShift Container Platform, identify two static IP addresses that are outside the DHCP lease pool.

   b. Connect to a host on this network and verify that each of the IP addresses is not in use. For example, use Address Resolution Protocol (ARP) to check that none of the IP addresses have entries:

   ```
   $ arp 10.35.1.19
   ```

   Example output

   ```
   10.35.1.19 (10.35.1.19) -- no entry
   ```

   c. Reserve two static IP addresses following the standard practices for your network environment.

   d. Record these IP addresses for future reference.

2. Create DNS entries for the OpenShift Container Platform REST API and apps domain names using this format:

   ```
   api.<cluster-name>.<base-domain>   <ip-address> 1
   *.apps.<cluster-name>.<base-domain>   <ip-address> 2
   ```

   1 For **<cluster-name>**, **<base-domain>**, and **<ip-address>**, specify the cluster name, base domain, and static IP address of your OpenShift Container Platform API.

   2 Specify the cluster name, base domain, and static IP address of your OpenShift Container Platform apps for Ingress and the load balancer.

   For example:

   ```
   api.my-cluster.virtlab.example.com 10.35.1.19
   *.apps.my-cluster.virtlab.example.com 10.35.1.20
   ```

20.3.6. Installing OpenShift Container Platform on RHV in insecure mode

By default, the installer creates a CA certificate, prompts you for confirmation, and stores the certificate to use during installation. You do not need to create or install one manually.

Although it is not recommended, you can override this functionality and install OpenShift Container Platform without verifying a certificate by installing OpenShift Container Platform on RHV in **insecure** mode.

WARNING

Installing in **insecure** mode is not recommended, because it enables a potential attacker to perform a Man-in-the-Middle attack and capture sensitive credentials on the network.

Procedure

1. Create a file named **~/.ovirt/ovirt-config.yaml**.
2. Add the following content to **ovirt-config.yaml**:

```
ovirt_url: https://ovirt.example.com/ovirt-engine/api (1)
ovirt_fqdn: ovirt.example.com (2)
ovirt_pem_url: ""
ovirt_username: ocpadmin@internal
ovirt_password: super-secret-password (3)
ovirt_insecure: true
```

(1) Specify the hostname or address of your oVirt engine.

(2) Specify the fully qualified domain name of your oVirt engine.

(3) Specify the admin password for your oVirt engine.

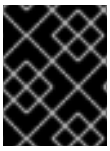
3. Run the installer.

20.3.7. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the **~/.ssh/authorized_keys** list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The **./openshift-install gather** command also requires the SSH public key to be in place on the cluster nodes.



IMPORTANT

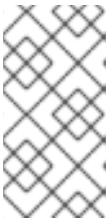
Do not skip this procedure in production environments, where disaster recovery and debugging is required.

Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N '' -f <path>/<file_name> 1
```

1 Specify the path and file name, such as ~/**.ssh/id_ed25519**, of the new SSH key. If you have an existing key pair, ensure your public key is in the your ~/**.ssh** directory.



NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS validated or Modules In Process cryptographic libraries on the **x86_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the ~/**.ssh/id_ed25519.pub** public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the **./openshift-install gather** command.

NOTE

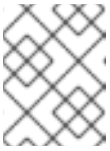
On some distributions, default SSH private key identities such as ~/**.ssh/id_rsa** and ~/**.ssh/id_dsa** are managed automatically.

a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

Example output

```
Agent pid 31874
```



NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

1 Specify the path and file name for your SSH private key, such as **~/.ssh/id_ed25519**

Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

20.3.8. Obtaining the installation program

Before you install OpenShift Container Platform, download the installation file on a local computer.

Prerequisites

- You have a computer that runs Linux or macOS, with 500 MB of local disk space.

Procedure

1. Access the Infrastructure Provider page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program that corresponds with your host operating system and architecture, and place the file in the directory where you will store the installation configuration files.

IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.

IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation pull secret from the Red Hat OpenShift Cluster Manager . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

20.3.9. Creating the installation configuration file

You can customize the OpenShift Container Platform cluster you install on Red Hat Virtualization (RHV).

Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.
- Obtain service principal permissions at the subscription level.

Procedure

1. Create the **install-config.yaml** file.
   a. Change to the directory that contains the installation program and run the following command:

```
$ ./openshift-install create install-config --dir <installation_directory> 1
```

   1 For **<installation_directory>**, specify the directory name to store the files that the installation program creates.

   When specifying the directory:

   - Verify that the directory has the **execute** permission. This permission is required to run Terraform binaries under the installation directory.
   - Use an empty directory. Some installation assets, such as bootstrap X.509 certificates, have short expiration intervals, therefore you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

   b. Respond to the installation program prompts.
      i. For **SSH Public Key**, select a password-less public key, such as **~/.ssh/id_rsa.pub**. This key authenticates connections with the new OpenShift Container Platform cluster.

NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, select an SSH key that your **ssh-agent** process uses.

ii. For **Platform**, select **ovirt**.

iii. For **Enter oVirt's API endpoint URL**, enter the URL of the RHV API using this format:

```
https://<engine-fqdn>/ovirt-engine/api 1
```

1 For **<engine-fqdn>**, specify the fully qualified domain name of the RHV environment.

For example:

```
$ curl -k -u ocpadmin@internal:pw123 \
https://rhv-env.virtlab.example.com/ovirt-engine/api
```

iv. For **Is the oVirt CA trusted locally?**, enter **Yes**, because you have already set up a CA certificate. Otherwise, enter **No**.

v. For **oVirt's CA bundle**, if you entered **Yes** for the preceding question, copy the certificate content from **/etc/pki/ca-trust/source/anchors/ca.pem** and paste it here. Then, press **Enter** twice. Otherwise, if you entered **No** for the preceding question, this question does not appear.

vi. For **oVirt engine username**, enter the user name and profile of the RHV administrator using this format:

```
<username>@<profile> 1
```

1 For **<username>**, specify the user name of an RHV administrator. For **<profile>**, specify the login profile, which you can get by going to the RHV Administration Portal login page and reviewing the **Profile** dropdown list. Together, the user name and profile should look similar to this example:

```
ocpadmin@internal
```

vii. For **oVirt engine password**, enter the RHV admin password.

viii. For **oVirt cluster**, select the cluster for installing OpenShift Container Platform.

ix. For **oVirt storage domain**, select the storage domain for installing OpenShift Container Platform.

x. For **oVirt network**, select a virtual network that has access to the RHV Manager REST API.

xi. For **Internal API Virtual IP**, enter the static IP address you set aside for the cluster's REST API.

xii. For **Ingress virtual IP**, enter the static IP address you reserved for the wildcard apps domain.

xiii. For **Base Domain**, enter the base domain of the OpenShift Container Platform cluster. If this cluster is exposed to the outside world, this must be a valid domain recognized by DNS infrastructure. For example, enter: **virtlab.example.com**

xiv. For **Cluster Name**, enter the name of the cluster. For example, **my-cluster**. Use cluster name from the externally registered/resolvable DNS entries you created for the OpenShift Container Platform REST API and apps domain names. The installation program also gives this name to the cluster in the RHV environment.

xv. For **Pull Secret**, copy the pull secret from the **pull-secret.txt** file you downloaded earlier and paste it here. You can also get a copy of the same pull secret from the Red Hat OpenShift Cluster Manager.

2. Modify the **install-config.yaml** file. You can find more information about the available parameters in the "Installation configuration parameters" section.

NOTE

If you have any intermediate CA certificates on the Manager, verify that the certificates appear in the **ovirt-config.yaml** file and the **install-config.yaml** file. If they do not appear, add them as follows:

1. In the **~/.ovirt/ovirt-config.yaml** file:

```
[ovirt_ca_bundle]: |
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA>
    -----END CERTIFICATE-----
    -----BEGIN CERTIFICATE-----
    <INTERMEDIATE_CA>
    -----END CERTIFICATE-----
```

2. In the **install-config.yaml** file:

```
[additionalTrustBundle]: |
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA>
    -----END CERTIFICATE-----
    -----BEGIN CERTIFICATE-----
    <INTERMEDIATE_CA>
    -----END CERTIFICATE-----
```

3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.

IMPORTANT

The **install-config.yaml** file is consumed during the installation process. If you want to reuse the file, you must back it up now.

20.3.9.1. Example install-config.yaml files for Red Hat Virtualization (RHV)

You can customize the OpenShift Container Platform cluster the installation program creates by changing the parameters and parameter values in the **install-config.yaml** file.

The following examples are specific to installing OpenShift Container Platform on RHV.

install-config.yaml is located in **<installation_directory>**, which you specified when you ran the following command.

```
$ ./openshift-install create install-config --dir <installation_directory>
```

NOTE

- These example files are provided for reference only. You must obtain your **install-config.yaml** file by using the installation program.
- Changing the **install-config.yaml** file can increase the resources your cluster requires. Verify that your RHV environment has those additional resources. Otherwise, the installation or cluster will fail.

Example default install-config.yaml file

```
apiVersion: v1
baseDomain: example.com
compute:
- architecture: amd64
  hyperthreading: Enabled
  name: worker
  platform:
    ovirt:
      sparse: false 1
      format: raw 2
  replicas: 3
controlPlane:
  architecture: amd64
  hyperthreading: Enabled
  name: master
  platform:
      ovirt:
        sparse: false 3
        format: raw 4
  replicas: 3
metadata:
  creationTimestamp: null
  name: my-cluster
networking:
  clusterNetwork:
  - cidr: 10.128.0.0/14
    hostPrefix: 23
  machineNetwork:
  - cidr: 10.0.0.0/16
  networkType: OpenShiftSDN
  serviceNetwork:
  - 172.30.0.0/16
platform:
```

```
  ovirt:
    api_vip: 10.46.8.230
    ingress_vip: 192.168.1.5
    ovirt_cluster_id: 68833f9f-e89c-4891-b768-e2ba0815b76b
    ovirt_storage_domain_id: ed7b0f4e-0e96-492a-8fff-279213ee1468
    ovirt_network_name: ovirtmgmt
    vnicProfileID: 3fa86930-0be5-4052-b667-b79f0a729692
publish: External
pullSecret: '{"auths": ...}'
sshKey: ssh-ed12345 AAAA...
```

1 3 Setting this option to **false** enables preallocation of disks. The default is **true**. Setting **sparse** to **true** with **format** set to **raw** is not available for block storage domains. The **raw** format writes the entire virtual disk to the underlying physical disk.

2 4 Can be set to **cow** or **raw**. The default is **cow**. The **cow** format is optimized for virtual machines.

NOTE

Preallocating disks on file storage domains writes zeroes to the file. This might not actually preallocate disks depending on the underlying storage.

Example minimal install-config.yaml file

```
apiVersion: v1
baseDomain: example.com
metadata:
  name: test-cluster
platform:
  ovirt:
    api_vip: 10.46.8.230
    ingress_vip: 10.46.8.232
    ovirt_cluster_id: 68833f9f-e89c-4891-b768-e2ba0815b76b
    ovirt_storage_domain_id: ed7b0f4e-0e96-492a-8fff-279213ee1468
    ovirt_network_name: ovirtmgmt
    vnicProfileID: 3fa86930-0be5-4052-b667-b79f0a729692
pullSecret: '{"auths": ...}'
sshKey: ssh-ed12345 AAAA...
```

Example Custom machine pools in an install-config.yaml file

```
apiVersion: v1
baseDomain: example.com
controlPlane:
  name: master
  platform:
    ovirt:
      cpu:
        cores: 4
        sockets: 2
      memoryMB: 65536
      osDisk:
        sizeGB: 100
      vmType: server
```

```
  replicas: 3
compute:
- name: worker
  platform:
    ovirt:
      cpu:
        cores: 4
        sockets: 4
      memoryMB: 65536
      osDisk:
        sizeGB: 200
      vmType: server
  replicas: 5
metadata:
  name: test-cluster
platform:
  ovirt:
    api_vip: 10.46.8.230
    ingress_vip: 10.46.8.232
    ovirt_cluster_id: 68833f9f-e89c-4891-b768-e2ba0815b76b
    ovirt_storage_domain_id: ed7b0f4e-0e96-492a-8fff-279213ee1468
    ovirt_network_name: ovirtmgmt
    vnicProfileID: 3fa86930-0be5-4052-b667-b79f0a729692
pullSecret: '{"auths": ...}'
sshKey: ssh-ed25519 AAAA...
```

Example non-enforcing affinity group

It is recommended to add a non-enforcing affinity group to distribute the control plane and workers, if possible, to use as much of the cluster as possible.

```
platform:
  ovirt:
    affinityGroups:
    - description: AffinityGroup to place each compute machine on a separate host
      enforcing: true
      name: compute
      priority: 3
    - description: AffinityGroup to place each control plane machine on a separate host
      enforcing: true
      name: controlplane
      priority: 5
    - description: AffinityGroup to place worker nodes and control plane nodes on separate hosts
      enforcing: false
      name: openshift
      priority: 5
compute:
- architecture: amd64
  hyperthreading: Enabled
  name: worker
  platform:
    ovirt:
      affinityGroupsNames:
      - compute
      - openshift
  replicas: 3
controlPlane:
```

```
  architecture: amd64
  hyperthreading: Enabled
  name: master
  platform:
    ovirt:
      affinityGroupsNames:
      - controlplane
      - openshift
  replicas: 3
```

Example removing all affinity groups for a non-production lab setup
For non-production lab setups, you must remove all affinity groups to concentrate the OpenShift Container Platform cluster on the few hosts you have.

```
platform:
  ovirt:
    affinityGroups: []
compute:
- architecture: amd64
  hyperthreading: Enabled
  name: worker
  platform:
    ovirt:
      affinityGroupsNames: []
  replicas: 3
controlPlane:
  architecture: amd64
  hyperthreading: Enabled
  name: master
  platform:
    ovirt:
      affinityGroupsNames: []
  replicas: 3
```

20.3.9.2. Installation configuration parameters

Before you deploy an OpenShift Container Platform cluster, you provide parameter values to describe your account on the cloud platform that hosts your cluster and optionally customize your cluster's platform. When you create the **install-config.yaml** installation configuration file, you provide values for the required parameters through the command line. If you customize your cluster, you can modify the **install-config.yaml** file to provide more details about the platform.

NOTE

After installation, you cannot modify these parameters in the **install-config.yaml** file.

20.3.9.2.1. Required configuration parameters

Required installation configuration parameters are described in the following table:

Table 20.1. Required parameters

Parameter	Description	Values
apiVersion	The API version for the **install-config.yaml** content. The current version is **v1**. The installer may also support older API versions.	String
baseDomain	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the **baseDomain** and **metadata.name** parameter values that uses the **<metadata.name>.<baseDomain>** format.	A fully-qualified domain or subdomain name, such as **example.com**.
metadata	Kubernetes resource **ObjectMeta**, from which only the **name** parameter is consumed.	Object
metadata.name	The name of the cluster. DNS records for the cluster are all subdomains of **{{.metadata.name}}.{{.baseDomain}}**.	String of lowercase letters, hyphens (**-**), and periods (**.**), such as **dev**.
platform	The configuration for the specific platform upon which to perform the installation: **alibabacloud**, **aws**, **baremetal**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**. For additional information about **platform.<platform>** parameters, consult the table for your specific platform that follows.	Object

Parameter	Description	Values
pullSecret	Get a pull secret from the Red Hat OpenShift Cluster Manager to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	<pre>{ "auths":{ "cloud.openshift.com":{ "auth":"b3Blb=", "email":"you@example.com" }, "quay.io":{ "auth":"b3Blb=", "email":"you@example.com" } } }</pre>

20.3.9.2.2. Network configuration parameters

You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

Only IPv4 addresses are supported.

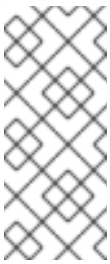
NOTE

Globalnet is not supported with Red Hat OpenShift Data Foundation disaster recovery solutions. For regional disaster recovery scenarios, ensure that you use a nonoverlapping range of private IP addresses for the cluster and service networks in each cluster.

Table 20.2. Network parameters

Parameter	Description	Values
networking	The configuration for the cluster network.	Object  **NOTE** You cannot modify parameters specified by the **networking** object after installation.

Parameter	Description	Values
networking.networkType	The cluster network provider Container Network Interface (CNI) cluster network provider to install.	Either **OpenShiftSDN** or **OVNKubernetes**. **OpenShiftSDN** is a CNI provider for all-Linux networks. **OVNKubernetes** is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is **OpenShiftSDN**.
networking.clusterNetwork	The IP address blocks for pods. The default value is **10.128.0.0/14** with a host prefix of **/23**. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: `networking:` `  clusterNetwork:` `  - cidr: 10.128.0.0/14` `    hostPrefix: 23`
networking.clusterNetwork.cidr	Required if you use **networking.clusterNetwork**. An IP address block. An IPv4 network.	An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between **0** and **32**.
networking.clusterNetwork.hostPrefix	The subnet prefix length to assign to each individual node. For example, if **hostPrefix** is set to **23** then each node is assigned a **/23** subnet out of the given **cidr**. A **hostPrefix** value of **23** provides 510 (2^(32 - 23) - 2) pod IP addresses.	A subnet prefix. The default value is **23**.
networking.serviceNetwork	The IP address block for services. The default value is **172.30.0.0/16**. The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.	An array with an IP address block in CIDR format. For example: `networking:` `  serviceNetwork:` `  - 172.30.0.0/16`
networking.machineNetwork	The IP address blocks for machines. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: `networking:` `  machineNetwork:` `  - cidr: 10.0.0.0/16`

Parameter	Description	Values
networking.machineNetwork.cidr	Required if you use **networking.machineNetwork**. An IP address block. The default value is **10.0.0.0/16** for all platforms other than libvirt. For libvirt, the default value is **192.168.126.0/24**.	An IP network block in CIDR notation. For example, **10.0.0.0/16**.  **NOTE** Set the **networking.machineNetwork** to match the CIDR that the preferred NIC resides in.

20.3.9.2.3. Optional configuration parameters

Optional installation configuration parameters are described in the following table:

Table 20.3. Optional parameters

Parameter	Description	Values
additionalTrustBundle	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String
capabilities	Controls the installation of optional core cluster components. You can reduce the footprint of your OpenShift Container Platform cluster by disabling optional components.	String array
capabilities.baselineCapabilitySet	Selects an initial set of optional capabilities to enable. Valid values are **None**, **v4.11** and **vCurrent**. **v4.11** enables the **baremetal** Operator, the **marketplace** Operator, and the **openshift-samples** content. **vCurrent** installs the recommended set of capabilities for the current version of OpenShift Container Platform. The default value is **vCurrent**.	String

Parameter	Description	Values
capabilities.additionalEnabledCapabilities	Extends the set of optional capabilities beyond what you specify in **baselineCapabilitySet**. Valid values are **baremetal**, **marketplace** and **openshift-samples**. You may specify multiple capabilities in this parameter.	String array
cgroupsV2	Enables Linux control groups version 2 (cgroups v2) on specific nodes in your cluster. The OpenShift Container Platform process for enabling cgroups v2 disables all cgroup version 1 controllers and hierarchies. The OpenShift Container Platform cgroups version 2 feature is in Developer Preview and is not supported by Red Hat at this time.	**true**
compute	The configuration for the machines that comprise the compute nodes.	Array of **MachinePool** objects. For details, see the "Additional RHV parameters for machine pools" table.
compute.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** (the default).	String
compute.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  IMPORTANT If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
compute.name	Required if you use **compute**. The name of the machine pool.	**worker**

Parameter	Description	Values
compute.platform	Required if you use **compute**. Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the **controlPlane.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
compute.replicas	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to **2**. The default value is **3**.
controlPlane	The configuration for the machines that comprise the control plane.	Array of **MachinePool** objects. For details, see the "Additional RHV parameters for machine pools" table.
controlPlane.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** (the default).	String
controlPlane.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  IMPORTANT If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
controlPlane.name	Required if you use **controlPlane**. The name of the machine pool.	**master**

Parameter	Description	Values
controlPlane.platform	Required if you use **controlPlane**. Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the **compute.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
controlPlane.replicas	The number of control plane machines to provision.	The only supported value is **3**, which is the default value.
credentialsMode	The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported.  **NOTE** Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the *Cloud Credential Operator* entry in the *Cluster Operators reference* content.  **NOTE** If your AWS account has service control policies (SCP) enabled, you must configure the **credentialsMode** parameter to **Mint**, **Passthrough** or **Manual**.	**Mint**, **Passthrough**, **Manual** or an empty string (**""**).

Parameter	Description	Values
fips	Enable or disable FIPS mode. The default is **false** (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.  **IMPORTANT** To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.  **NOTE** If you are using Azure File storage, you cannot enable FIPS mode.	**false** or **true**
imageContentSources	Sources and repositories for the release-image content.	Array of objects. Includes a **source** and, optionally, **mirrors**, as described in the following rows of this table.
imageContentSources.source	Required if you use **imageContentSources**. Specify the repository that users refer to, for example, in image pull specifications.	String
imageContentSources.mirrors	Specify one or more repositories that may also contain the same images.	Array of strings

Parameter	Description	Values
publish	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	**Internal** or **External**. The default value is **External**. Setting this field to **Internal** is not supported on non-cloud platforms and IBM Cloud VPC.  **IMPORTANT** If the value of the field is set to **Internal**, the cluster will become non-functional. For more information, refer to BZ#1953035.
sshKey	The SSH key to authenticate access to your cluster machines.  **NOTE** For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.	For example, **sshKey: ssh-ed25519 AAAA..**.

20.3.9.2.4. Additional Red Hat Virtualization (RHV) configuration parameters

Additional RHV configuration parameters are described in the following table:

Table 20.4. Additional Red Hat Virtualization (RHV) parameters for clusters

Parameter	Description	Values
platform.ovirt.ovirt_cluster_id	Required. The Cluster where the VMs will be created.	String. For example: **68833f9f-e89c-4891-b768-e2ba0815b76b**
platform.ovirt.ovirt_storage_domain_id	Required. The Storage Domain ID where the VM disks will be created.	String. For example: **ed7b0f4e-0e96-492a-8fff-279213ee1468**
platform.ovirt.ovirt_network_name	Required. The network name where the VM nics will be created.	String. For example: **ocpcluster**

Parameter	Description	Values
platform.ovirt.vnicProfileID	Required. The vNIC profile ID of the VM network interfaces. This can be inferred if the cluster network has a single profile.	String. For example: **3fa86930-0be5-4052-b667-b79f0a729692**
platform.ovirt.api_vip	Required. An IP address on the machine network that will be assigned to the API virtual IP (VIP). You can access the OpenShift API at this endpoint.	String. Example: **10.46.8.230**
platform.ovirt.ingress_vip	Required. An IP address on the machine network that will be assigned to the Ingress virtual IP (VIP).	String. Example: **10.46.8.232**
platform.ovirt.affinityGroups	Optional. A list of affinity groups to create during the installation process.	List of objects.
platform.ovirt.affinityGroups.description	Required if you include **platform.ovirt.affinityGroups**. A description of the affinity group.	String. Example: **AffinityGroup for spreading each compute machine to a different host**
platform.ovirt.affinityGroups.enforcing	Required if you include **platform.ovirt.affinityGroups**. When set to **true**, RHV does not provision any machines if not enough hardware nodes are available. When set to **false**, RHV does provision machines even if not enough hardware nodes are available, resulting in multiple virtual machines being hosted on the same physical machine.	String. Example: **true**
platform.ovirt.affinityGroups.name	Required if you include **platform.ovirt.affinityGroups**. The name of the affinity group.	String. Example: **compute**
platform.ovirt.affinityGroups.priority	Required if you include **platform.ovirt.affinityGroups**. The priority given to an affinity group when **platform.ovirt.affinityGroups.enforcing = false**. RHV applies affinity groups in the order of priority, where a greater number takes precedence over a lesser one. If multiple affinity groups have the same priority, the order in which they are applied is not guaranteed.	Integer. Example: **3**

20.3.9.2.5. Additional RHV parameters for machine pools

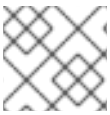
Additional RHV configuration parameters for machine pools are described in the following table:

Table 20.5. Additional RHV parameters for machine pools

Parameter	Description	Values
<machine-pool>.platform.ovirt.cpu	Optional. Defines the CPU of the VM.	Object
<machine-pool>.platform.ovirt.cpu.cores	Required if you use **<machine-pool>.platform.ovirt.cpu**. The number of cores. Total virtual CPUs (vCPUs) is cores * sockets.	Integer
<machine-pool>.platform.ovirt.cpu.sockets	Required if you use **<machine-pool>.platform.ovirt.cpu**. The number of sockets per core. Total virtual CPUs (vCPUs) is cores * sockets.	Integer
<machine-pool>.platform.ovirt.memoryMB	Optional. Memory of the VM in MiB.	Integer
<machine-pool>.platform.ovirt.osDisk	Optional. Defines the first and bootable disk of the VM.	String
<machine-pool>.platform.ovirt.osDisk.sizeGB	Required if you use **<machine-pool>.platform.ovirt.osDisk**. Size of the disk in GiB.	Number

Parameter	Description	Values
<machine-pool>.platform.ovirt.vmType	Optional. The VM workload type, such as **high-performance**, **server**, or **desktop**. By default, control plane nodes use **high-performance**, and worker nodes use **server**. For details, see Explanation of Settings in the New Virtual Machine and Edit Virtual Machine Windows and Configuring High Performance Virtual Machines, Templates, and Pools in the *Virtual Machine Management Guide*.  **NOTE** **high_performance** improves performance on the VM, but there are limitations. For example, you cannot access the VM with a graphical console. For more information, see Configuring High Performance Virtual Machines, Templates, and Pools in the *Virtual Machine Management Guide*.	String

Parameter	Description	Values
<machine-pool>.platform.ovirt.affinityGroupsNames	Optional. A list of affinity group names that should be applied to the virtual machines. The affinity groups must exist in RHV, or be created during installation as described in *Additional RHV parameters for clusters* in this topic. This entry can be empty. **Example with two affinity groups** This example defines two affinity groups, named **compute** and **clusterWideNonEnforcing**: `<machine-pool>:` `  platform:` `  ovirt:` `  affinityGroupNames:` `  - compute` `  - clusterWideNonEnforcing` This example defines no affinity groups: `<machine-pool>:` `  platform:` `  ovirt:` `  affinityGroupNames: []`	String
<machine-pool>.platform.ovirt.AutoPinningPolicy	Optional. AutoPinningPolicy defines the policy to automatically set the CPU and NUMA settings, including pinning to the host for the instance. When the field is omitted, the default is **none**. Supported values: **none**, **resize_and_pin**. For more information, see Setting NUMA Nodes in the *Virtual Machine Management Guide*.	String
<machine-pool>.platform.ovirt.hugepages	Optional. Hugepages is the size in KiB for defining hugepages in a VM. Supported values: **2048** or **1048576**. For more information, see Configuring Huge Pages in the *Virtual Machine Management Guide*.	Integer



NOTE

You can replace **<machine-pool>** with **controlPlane** or **compute**.

20.3.10. Deploying the cluster

You can install OpenShift Container Platform on a compatible cloud platform.

IMPORTANT

You can run the **create cluster** command of the installation program only once, during initial installation.

Prerequisites

- Open the **ovirt-imageio** port to the Manager from the machine running the installer. By default, the port is **54322**.
- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.

Procedure

- Change to the directory that contains the installation program and initialize the cluster deployment:

```
$ ./openshift-install create cluster --dir <installation_directory> \ 1
    --log-level=info 2
```

1 For **<installation_directory>**, specify the location of your customized **./install-config.yaml** file.

2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

NOTE

If the cloud provider account that you configured on your host does not have sufficient permissions to deploy the cluster, the installation process stops, and the missing permissions are displayed.

Verification

When the cluster deployment completes successfully:

- The terminal displays directions for accessing your cluster, including a link to the web console and credentials for the **kubeadmin** user.
- Credential information also outputs to **<installation_directory>/.openshift_install.log**.

IMPORTANT

Do not delete the installation program or the files that the installation program creates. Both are required to delete the cluster.

Example output

```
...
```

```
INFO Install complete!
INFO To access the cluster as the system:admin user when using 'oc', run 'export
KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
INFO Access the OpenShift web-console here: https://console-openshift-
console.apps.mycluster.example.com
INFO Login to the console with user: "kubeadmin", and password: "password"
INFO Time elapsed: 36m22s
```

IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

IMPORTANT

You have completed the steps required to install the cluster. The remaining steps show you how to verify the cluster and troubleshoot the installation.

20.3.11. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.

IMPORTANT

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.11. Download and install the new version of **oc**.

Installing the OpenShift CLI on Linux

You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the architecture in the **Product Variant** drop-down menu.
3. Select the appropriate version in the **Version** drop-down menu.
4. Click **Download Now** next to the **OpenShift v4.11 Linux Client** entry and save the file.
5. Unpack the archive:

```
$ tar xvf <file>
```

6. Place the **oc** binary in a directory that is on your **PATH**.
   To check your **PATH**, execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.
   To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

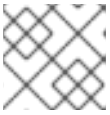
```
C:\> oc <command>
```

Installing the OpenShift CLI on macOS

You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 macOS Client** entry and save the file.



NOTE

For macOS arm64, choose the **OpenShift v4.11 macOS arm64 Client** entry.

4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your PATH.
   To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

20.3.12. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

Example output

```
system:admin
```

To learn more, see Getting started with the OpenShift CLI.

20.3.13. Verifying cluster status

You can verify your OpenShift Container Platform cluster's status during or after installation.

Procedure

1. In the cluster environment, export the administrator's kubeconfig file:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server.

2. View the control plane and compute machines created after a deployment:

```
$ oc get nodes
```

3. View your cluster's version:

```
$ oc get clusterversion
```

4. View your Operators' status:

```
$ oc get clusteroperator
```

5. View all running pods in the cluster:

```
$ oc get pods -A
```

Troubleshooting

If the installation fails, the installation program times out and displays an error message. To learn more, see Troubleshooting installation issues.

20.3.14. Accessing the OpenShift Container Platform web console on RHV

After the OpenShift Container Platform cluster initializes, you can log in to the OpenShift Container Platform web console.

Procedure

1. Optional: In the Red Hat Virtualization (RHV) Administration Portal, open **Compute → Cluster**.
2. Verify that the installation program creates the virtual machines.
3. Return to the command line where the installation program is running. When the installation program finishes, it displays the user name and temporary password for logging into the OpenShift Container Platform web console.
4. In a browser, open the URL of the OpenShift Container Platform web console. The URL uses this format:

```
console-openshift-console.apps.<clustername>.<basedomain> 1
```

1 For **<clustername>.<basedomain>**, specify the cluster name and base domain.

For example:

```
console-openshift-console.apps.my-cluster.virtlab.example.com
```

20.3.15. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.11, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to OpenShift Cluster Manager Hybrid Cloud Console.

After you confirm that your OpenShift Cluster Manager Hybrid Cloud Console inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, use subscription watch to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

Additional resources

- See About remote health monitoring for more information about the Telemetry service

20.3.16. Troubleshooting common issues with installing on Red Hat Virtualization (RHV)

Here are some common issues you might encounter, along with proposed causes and solutions.

20.3.16.1. CPU load increases and nodes go into a **Not Ready** state

- **Symptom**: CPU load increases significantly and nodes start going into a **Not Ready** state.
- **Cause**: The storage domain latency might be too high, especially for control plane nodes.
- **Solution**:
  Make the nodes ready again by restarting the kubelet service:

  ```
  $ systemctl restart kubelet
  ```

  Inspect the OpenShift Container Platform metrics service, which automatically gathers and reports on some valuable data such as the etcd disk sync duration. If the cluster is operational, use this data to help determine whether storage latency or throughput is the root issue. If so, consider using a storage resource that has lower latency and higher throughput.

  To get raw metrics, enter the following command as kubeadmin or user with cluster-admin privileges:

  ```
  $ oc get --insecure-skip-tls-verify --server=https://localhost:<port> --raw=/metrics
  ```

  To learn more, see Exploring Application Endpoints for the purposes of Debugging with OpenShift 4.x

20.3.16.2. Trouble connecting the OpenShift Container Platform cluster API

- **Symptom**: The installation program completes but the OpenShift Container Platform cluster API is not available. The bootstrap virtual machine remains up after the bootstrap process is complete. When you enter the following command, the response will time out.

  ```
  $ oc login -u kubeadmin -p *** <apiurl>
  ```

- **Cause**: The bootstrap VM was not deleted by the installation program and has not released the cluster's API IP address.

- **Solution**: Use the **wait-for** subcommand to be notified when the bootstrap process is complete:

  ```
  $ ./openshift-install wait-for bootstrap-complete
  ```

  When the bootstrap process is complete, delete the bootstrap virtual machine:

  ```
  $ ./openshift-install destroy bootstrap
  ```

20.3.17. Post-installation tasks

After the OpenShift Container Platform cluster initializes, you can perform the following tasks.

- Optional: After deployment, add or replace SSH keys using the Machine Config Operator (MCO) in OpenShift Container Platform.
- Optional: Remove the **kubeadmin** user. Instead, use the authentication provider to create a user with cluster-admin privileges.

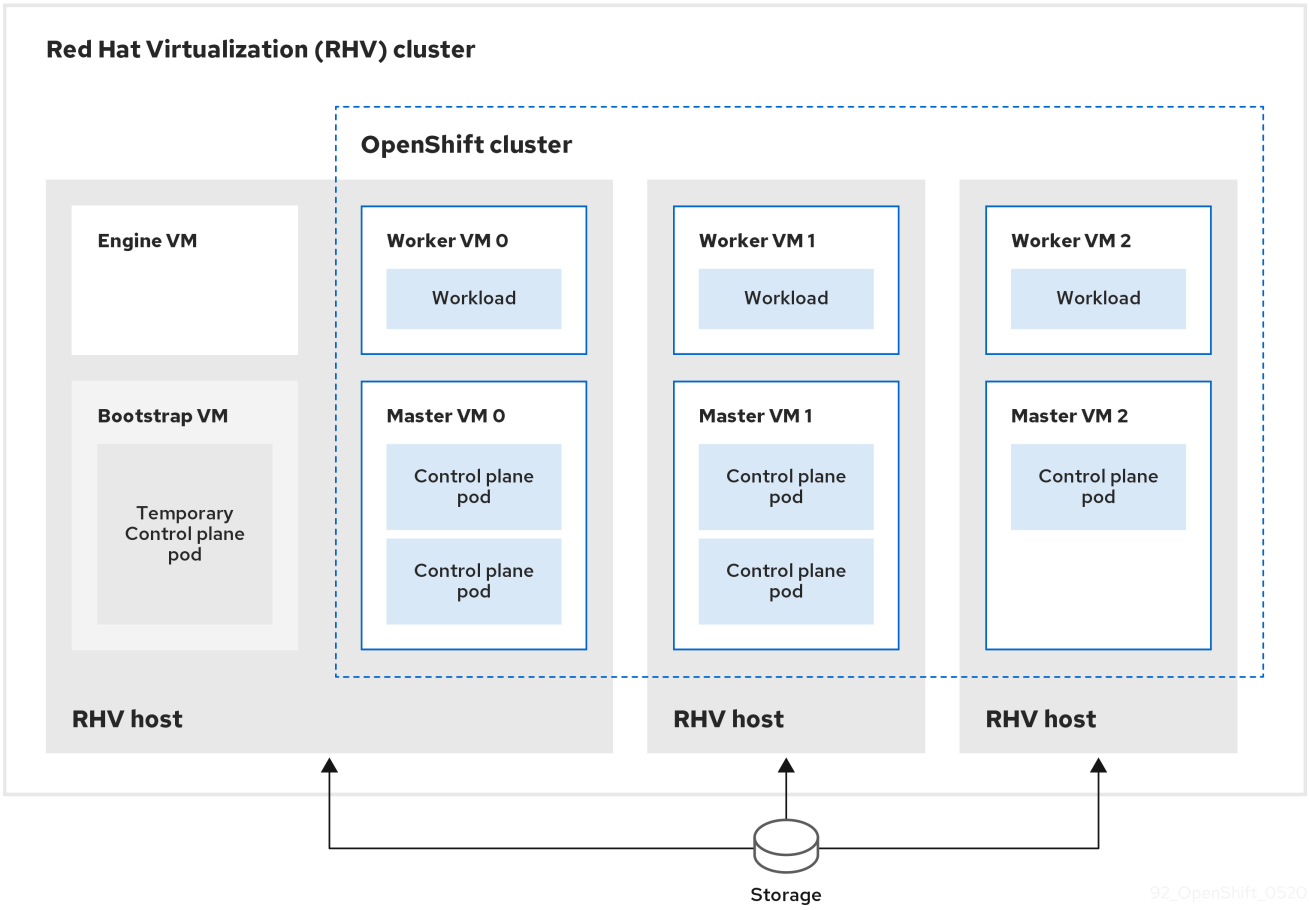
20.3.18. Next steps

- Customize your cluster.
- If necessary, you can opt out of remote health reporting .

20.4. INSTALLING A CLUSTER ON RHV WITH USER-PROVISIONED INFRASTRUCTURE

In OpenShift Container Platform version 4.11, you can install a customized OpenShift Container Platform cluster on Red Hat Virtualization (RHV) and other infrastructure that you provide. The OpenShift Container Platform documentation uses the term *user-provisioned infrastructure* to refer to this infrastructure type.

The following diagram shows an example of a potential OpenShift Container Platform cluster running on a RHV cluster.



The RHV hosts run virtual machines that contain both control plane and compute pods. One of the hosts also runs a Manager virtual machine and a bootstrap virtual machine that contains a temporary control plane pod.]

20.4.1. Prerequisites

The following items are required to install an OpenShift Container Platform cluster on a RHV environment.

- You reviewed details about the OpenShift Container Platform installation and update processes.
- You read the documentation on selecting a cluster installation method and preparing it for users.
- You have a supported combination of versions in the Support Matrix for OpenShift Container Platform on Red Hat Virtualization (RHV).

20.4.2. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.11, you require access to the internet to install your cluster.

You must have internet access to:

- Access OpenShift Cluster Manager Hybrid Cloud Console to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.

- Access Quay.io to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.

IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

20.4.3. Requirements for the RHV environment

To install and run an OpenShift Container Platform version 4.11 cluster, the RHV environment must meet the following requirements.

Not meeting these requirements can cause the installation or process to fail. Additionally, not meeting these requirements can cause the OpenShift Container Platform cluster to fail days or weeks after installation.

The following requirements for CPU, memory, and storage resources are based on **default** values multiplied by the default number of virtual machines the installation program creates. These resources must be available **in addition to** what the RHV environment uses for non-OpenShift Container Platform operations.

By default, the installation program creates seven virtual machines during the installation process. First, it creates a bootstrap virtual machine to provide temporary services and a control plane while it creates the rest of the OpenShift Container Platform cluster. When the installation program finishes creating the cluster, deleting the bootstrap machine frees up its resources.

If you increase the number of virtual machines in the RHV environment, you must increase the resources accordingly.

Requirements

- The RHV version is 4.4.
- The RHV environment has one data center whose state is **Up**.
- The RHV data center contains an RHV cluster.
- The RHV cluster has the following resources exclusively for the OpenShift Container Platform cluster:
  - Minimum 28 vCPUs: four for each of the seven virtual machines created during installation.
  - 112 GiB RAM or more, including:
    - 16 GiB or more for the bootstrap machine, which provides the temporary control plane.
    - 16 GiB or more for each of the three control plane machines which provide the control plane.

- 16 GiB or more for each of the three compute machines, which run the application workloads.

- The RHV storage domain must meet these etcd backend performance requirements.
- In production environments, each virtual machine must have 120 GiB or more. Therefore, the storage domain must provide 840 GiB or more for the default OpenShift Container Platform cluster. In resource-constrained or non-production environments, each virtual machine must have 32 GiB or more, so the storage domain must have 230 GiB or more for the default OpenShift Container Platform cluster.
- To download images from the Red Hat Ecosystem Catalog during installation and update procedures, the RHV cluster must have access to an internet connection. The Telemetry service also needs an internet connection to simplify the subscription and entitlement process.
- The RHV cluster must have a virtual network with access to the REST API on the RHV Manager. Ensure that DHCP is enabled on this network, because the VMs that the installer creates obtain their IP address by using DHCP.
- A user account and group with the following least privileges for installing and managing an OpenShift Container Platform cluster on the target RHV cluster:
  - **DiskOperator**
  - **DiskCreator**
  - **UserTemplateBasedVm**
  - **TemplateOwner**
  - **TemplateCreator**
  - **ClusterAdmin** on the target cluster

WARNING

Apply the principle of least privilege: Avoid using an administrator account with **SuperUser** privileges on RHV during the installation process. The installation program saves the credentials you provide to a temporary **ovirt-config.yaml** file that might be compromised.

20.4.4. Verifying the requirements for the RHV environment

Verify that the RHV environment meets the requirements to install and run an OpenShift Container Platform cluster. Not meeting these requirements can cause failures.

IMPORTANT

These requirements are based on the default resources the installation program uses to create control plane and compute machines. These resources include vCPUs, memory, and storage. If you change these resources or increase the number of OpenShift Container Platform machines, adjust these requirements accordingly.

Procedure

1. Check that the RHV version supports installation of OpenShift Container Platform version 4.11.
    a. In the RHV Administration Portal, click the **?** help icon in the upper-right corner and select **About**.
    b. In the window that opens, make a note of the **RHV Software Version**.
    c. Confirm that the RHV version is 4.4. For more information about supported version combinations, see Support Matrix for OpenShift Container Platform on RHV.
2. Inspect the data center, cluster, and storage.
    a. In the RHV Administration Portal, click **Compute → Data Centers**.
    b. Confirm that the data center where you plan to install OpenShift Container Platform is accessible.
    c. Click the name of that data center.
    d. In the data center details, on the **Storage** tab, confirm the storage domain where you plan to install OpenShift Container Platform is **Active**.
    e. Record the **Domain Name** for use later on.
    f. Confirm **Free Space** has at least 230 GiB.
    g. Confirm that the storage domain meets these etcd backend performance requirements, which you can measure by using the fio performance benchmarking tool.
    h. In the data center details, click the **Clusters** tab.
    i. Find the RHV cluster where you plan to install OpenShift Container Platform. Record the cluster name for use later on.
3. Inspect the RHV host resources.
    a. In the RHV Administration Portal, click **Compute > Clusters**.
    b. Click the cluster where you plan to install OpenShift Container Platform.
    c. In the cluster details, click the **Hosts** tab.
    d. Inspect the hosts and confirm they have a combined total of at least 28 **Logical CPU Cores** available *exclusively* for the OpenShift Container Platform cluster.
    e. Record the number of available **Logical CPU Cores** for use later on.
    f. Confirm that these CPU cores are distributed so that each of the seven virtual machines created during installation can have four cores.
    g. Confirm that, all together, the hosts have 112 GiB of **Max free Memory for scheduling new virtual machines** distributed to meet the requirements for each of the following OpenShift Container Platform machines:
        - 16 GiB required for the bootstrap machine
        - 16 GiB required for each of the three control plane machines

- 16 GiB for each of the three compute machines

h. Record the amount of **Max free Memory for scheduling new virtual machines** for use later on.

4. Verify that the virtual network for installing OpenShift Container Platform has access to the RHV Manager's REST API. From a virtual machine on this network, use curl to reach the RHV Manager's REST API:

```
$ curl -k -u <username>@<profile>:<password> \ 1
https://<engine-fqdn>/ovirt-engine/api 2
```

1 For **<username>**, specify the user name of an RHV account with privileges to create and manage an OpenShift Container Platform cluster on RHV. For **<profile>**, specify the login profile, which you can get by going to the RHV Administration Portal login page and reviewing the **Profile** dropdown list. For **<password>**, specify the password for that user name.

2 For **<engine-fqdn>**, specify the fully qualified domain name of the RHV environment.

For example:

```
$ curl -k -u ocpadmin@internal:pw123 \
https://rhv-env.virtlab.example.com/ovirt-engine/api
```

20.4.5. Networking requirements for user-provisioned infrastructure

All the Red Hat Enterprise Linux CoreOS (RHCOS) machines require networking to be configured in **initramfs** during boot to fetch their Ignition config files.

During the initial boot, the machines require an IP address configuration that is set either through a DHCP server or statically by providing the required boot options. After a network connection is established, the machines download their Ignition config files from an HTTP or HTTPS server. The Ignition config files are then used to set the exact state of each machine. The Machine Config Operator completes more changes to the machines, such as the application of new certificates or keys, after installation.

It is recommended to use a DHCP server for long-term management of the cluster machines. Ensure that the DHCP server is configured to provide persistent IP addresses, DNS server information, and hostnames to the cluster machines.

NOTE

If a DHCP service is not available for your user-provisioned infrastructure, you can instead provide the IP networking configuration and the address of the DNS server to the nodes at RHCOS install time. These can be passed as boot arguments if you are installing from an ISO image. See the *Installing RHCOS and starting the OpenShift Container Platform bootstrap process* section for more information about static IP provisioning and advanced networking options.

The Kubernetes API server must be able to resolve the node names of the cluster machines. If the API servers and worker nodes are in different zones, you can configure a default DNS search zone to allow the API server to resolve the node names. Another supported approach is to always refer to hosts by

their fully-qualified domain names in both the node objects and all DNS requests.

Firewall

Configure your firewall so your cluster has access to required sites.

See also:

- Red Hat Virtualization Manager firewall requirements
- Host firewall requirements

Load balancers

Configure one or preferably two layer-4 load balancers:

- Provide load balancing for ports **6443** and **22623** on the control plane and bootstrap machines. Port **6443** provides access to the Kubernetes API server and must be reachable both internally and externally. Port **22623** must be accessible to nodes within the cluster.
- Provide load balancing for port **443** and **80** for machines that run the Ingress router, which are usually compute nodes in the default configuration. Both ports must be accessible from within and outside the cluster.

DNS

Configure infrastructure-provided DNS to allow the correct resolution of the main components and services. If you use only one load balancer, these DNS records can point to the same IP address.

- Create DNS records for **api.<cluster_name>.<base_domain>** (internal and external resolution) and **api-int.<cluster_name>.<base_domain>** (internal resolution) that point to the load balancer for the control plane machines.
- Create a DNS record for ***.apps.<cluster_name>.<base_domain>** that points to the load balancer for the Ingress router. For example, ports **443** and **80** of the compute machines.

20.4.5.1. Setting the cluster node hostnames through DHCP

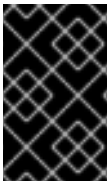
On Red Hat Enterprise Linux CoreOS (RHCOS) machines, the hostname is set through NetworkManager. By default, the machines obtain their hostname through DHCP. If the hostname is not provided by DHCP, set statically through kernel arguments, or another method, it is obtained through a reverse DNS lookup. Reverse DNS lookup occurs after the network has been initialized on a node and can take time to resolve. Other system services can start prior to this and detect the hostname as **localhost** or similar. You can avoid this by using DHCP to provide the hostname for each cluster node.

Additionally, setting the hostnames through DHCP can bypass any manual DNS record name configuration errors in environments that have a DNS split-horizon implementation.

20.4.5.2. Network connectivity requirements

You must configure the network connectivity between machines to allow OpenShift Container Platform cluster components to communicate. Each machine must be able to resolve the hostnames of all other machines in the cluster.

This section provides details about the ports that are required.



IMPORTANT

In connected OpenShift Container Platform environments, all nodes are required to have internet access to pull images for platform containers and provide telemetry data to Red Hat.

Table 20.6. Ports used for all-machine to all-machine communications

Protocol	Port	Description
ICMP	N/A	Network reachability tests
TCP	**1936**	Metrics
	9000-**9999**	Host level services, including the node exporter on ports **9100**-**9101** and the Cluster Version Operator on port**9099**.
	10250-**10259**	The default ports that Kubernetes reserves
	10256	openshift-sdn
UDP	**4789**	VXLAN
	6081	Geneve
	9000-**9999**	Host level services, including the node exporter on ports **9100**-**9101**.
	500	IPsec IKE packets
	4500	IPsec NAT-T packets
TCP/UDP	**30000**-**32767**	Kubernetes node port
ESP	N/A	IPsec Encapsulating Security Payload (ESP)

Table 20.7. Ports used for all-machine to control plane communications

Protocol	Port	Description
TCP	**6443**	Kubernetes API

Table 20.8. Ports used for control plane machine to control plane machine communications

Protocol	Port	Description
TCP	**2379**-**2380**	etcd server and peer ports

NTP configuration for user-provisioned infrastructure
OpenShift Container Platform clusters are configured to use a public Network Time Protocol (NTP) server by default. If you want to use a local enterprise NTP server, or if your cluster is being deployed in a disconnected network, you can configure the cluster to use a specific time server. For more information, see the documentation for *Configuring chrony time service* .

If a DHCP server provides NTP server information, the chrony time service on the Red Hat Enterprise Linux CoreOS (RHCOS) machines read the information and can sync the clock with the NTP servers.

20.4.6. Setting up the installation machine

To run the binary **openshift-install** installation program and Ansible scripts, set up the RHV Manager or an Red Hat Enterprise Linux (RHEL) computer with network access to the RHV environment and the REST API on the Manager.

Procedure

1. Update or install Python3 and Ansible. For example:

```
# dnf update python3 ansible
```

2. Install the **python3-ovirt-engine-sdk4** package to get the Python Software Development Kit.

3. Install the **ovirt.image-template** Ansible role. On the RHV Manager and other Red Hat Enterprise Linux (RHEL) machines, this role is distributed as the **ovirt-ansible-image-template** package. For example, enter:

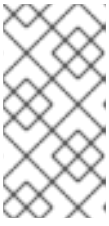
```
# dnf install ovirt-ansible-image-template
```

4. Install the **ovirt.vm-infra** Ansible role. On the RHV Manager and other RHEL machines, this role is distributed as the **ovirt-ansible-vm-infra** package.

```
# dnf install ovirt-ansible-vm-infra
```

5. Create an environment variable and assign an absolute or relative path to it. For example, enter:

```
$ export ASSETS_DIR=./wrk
```



NOTE

The installation program uses this variable to create a directory where it saves important installation-related files. Later, the installation process reuses this variable to locate those asset files. Avoid deleting this assets directory; it is required for uninstalling the cluster.

20.4.7. Installing OpenShift Container Platform on RHV in insecure mode

By default, the installer creates a CA certificate, prompts you for confirmation, and stores the certificate to use during installation. You do not need to create or install one manually.

Although it is not recommended, you can override this functionality and install OpenShift Container Platform without verifying a certificate by installing OpenShift Container Platform on RHV in **insecure** mode.

WARNING

Installing in **insecure** mode is not recommended, because it enables a potential attacker to perform a Man-in-the-Middle attack and capture sensitive credentials on the network.

Procedure

1. Create a file named **~/.ovirt/ovirt-config.yaml**.
2. Add the following content to **ovirt-config.yaml**:

```
ovirt_url: https://ovirt.example.com/ovirt-engine/api (1)
ovirt_fqdn: ovirt.example.com (2)
ovirt_pem_url: ""
ovirt_username: ocpadmin@internal
ovirt_password: super-secret-password (3)
ovirt_insecure: true
```

(1) Specify the hostname or address of your oVirt engine.

(2) Specify the fully qualified domain name of your oVirt engine.

(3) Specify the admin password for your oVirt engine.

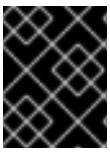
3. Run the installer.

20.4.8. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the **~/.ssh/authorized_keys** list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The **./openshift-install gather** command also requires the SSH public key to be in place on the cluster nodes.



IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.

NOTE

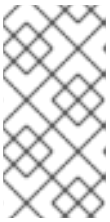
You must use a local key, not one that you configured with platform-specific approaches such as AWS key pairs.

Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N '' -f <path>/<file_name> 1
```

1 Specify the path and file name, such as ~/**.ssh/id_ed25519**, of the new SSH key. If you have an existing key pair, ensure your public key is in the your ~/**.ssh** directory.



NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS validated or Modules In Process cryptographic libraries on the **x86_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

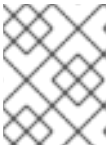
2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the ~/**.ssh/id_ed25519.pub** public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the **./openshift-install gather** command.



NOTE

On some distributions, default SSH private key identities such as ~/**.ssh/id_rsa** and ~/**.ssh/id_dsa** are managed automatically.

a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

Example output

```
Agent pid 31874
```

NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

1 Specify the path and file name for your SSH private key, such as **~/.ssh/id_ed25519**

Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

20.4.9. Obtaining the installation program

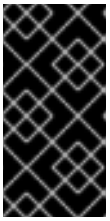
Before you install OpenShift Container Platform, download the installation file on a local computer.

Prerequisites

- You have a computer that runs Linux or macOS, with 500 MB of local disk space.

Procedure

1. Access the Infrastructure Provider page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program that corresponds with your host operating system and architecture, and place the file in the directory where you will store the installation configuration files.



IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.

IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation pull secret from the Red Hat OpenShift Cluster Manager . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

20.4.10. Downloading the Ansible playbooks

Download the Ansible playbooks for installing OpenShift Container Platform version 4.11 on RHV.

Procedure

- On your installation machine, run the following commands:

```
$ mkdir playbooks
```

```
$ cd playbooks
```

```
$  xargs -n 1 curl -O <<< '
      https://raw.githubusercontent.com/openshift/installer/release-4.11/upi/ovirt/bootstrap.yml
      https://raw.githubusercontent.com/openshift/installer/release-4.11/upi/ovirt/common-
auth.yml
      https://raw.githubusercontent.com/openshift/installer/release-4.11/upi/ovirt/create-
templates-and-vms.yml
      https://raw.githubusercontent.com/openshift/installer/release-4.11/upi/ovirt/inventory.yml
      https://raw.githubusercontent.com/openshift/installer/release-4.11/upi/ovirt/masters.yml
      https://raw.githubusercontent.com/openshift/installer/release-4.11/upi/ovirt/retire-
bootstrap.yml
      https://raw.githubusercontent.com/openshift/installer/release-4.11/upi/ovirt/retire-
masters.yml
      https://raw.githubusercontent.com/openshift/installer/release-4.11/upi/ovirt/retire-
workers.yml
      https://raw.githubusercontent.com/openshift/installer/release-4.11/upi/ovirt/workers.yml'
```

Next steps

- After you download these Ansible playbooks, you must also create the environment variable for the assets directory and customize the **inventory.yml** file before you create an installation configuration file by running the installation program.

20.4.11. The inventory.yml file

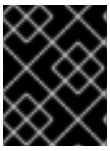
You use the **inventory.yml** file to define and create elements of the OpenShift Container Platform cluster you are installing. This includes elements such as the Red Hat Enterprise Linux CoreOS (RHCOS) image, virtual machine templates, bootstrap machine, control plane nodes, and worker nodes. You also use **inventory.yml** to destroy the cluster.

The following **inventory.yml** example shows you the parameters and their default values. The quantities and numbers in these default values meet the requirements for running a production OpenShift Container Platform cluster in a RHV environment.

Example inventory.yml file

```
---
all:
  vars:

    ovirt_cluster: "Default"
    ocp:
      assets_dir: "{{ lookup('env', 'ASSETS_DIR') }}"
      ovirt_config_path: "{{ lookup('env', 'HOME') }}/.ovirt/ovirt-config.yaml"

    # ---
    # {op-system} section
    # ---
    rhcos:
      image_url: "https://mirror.openshift.com/pub/openshift-v4/dependencies/rhcos/4.11/latest/rhcos-openstack.x86_64.qcow2.gz"
      local_cmp_image_path: "/tmp/rhcos.qcow2.gz"
      local_image_path: "/tmp/rhcos.qcow2"

    # ---
    # Profiles section
    # ---
    control_plane:
      cluster: "{{ ovirt_cluster }}"
      memory: 16GiB
      sockets: 4
      cores: 1
      template: rhcos_tpl
      operating_system: "rhcos_x64"
      type: high_performance
      graphical_console:
        headless_mode: false
        protocol:
        - spice
        - vnc
      disks:
      - size: 120GiB
        name: os
        interface: virtio_scsi
        storage_domain: depot_nvme
      nics:
      - name: nic1
        network: lab
        profile: lab

    compute:
      cluster: "{{ ovirt_cluster }}"
      memory: 16GiB
      sockets: 4
      cores: 1
      template: worker_rhcos_tpl
```

```
    operating_system: "rhcos_x64"
    type: high_performance
    graphical_console:
      headless_mode: false
      protocol:
      - spice
      - vnc
    disks:
    - size: 120GiB
      name: os
      interface: virtio_scsi
      storage_domain: depot_nvme
    nics:
    - name: nic1
      network: lab
      profile: lab

  # ---
  # Virtual machines section
  # ---
  vms:
  - name: "{{ metadata.infraID }}-bootstrap"
    ocp_type: bootstrap
    profile: "{{ control_plane }}"
    type: server
  - name: "{{ metadata.infraID }}-master0"
    ocp_type: master
    profile: "{{ control_plane }}"
  - name: "{{ metadata.infraID }}-master1"
    ocp_type: master
    profile: "{{ control_plane }}"
  - name: "{{ metadata.infraID }}-master2"
    ocp_type: master
    profile: "{{ control_plane }}"
  - name: "{{ metadata.infraID }}-worker0"
    ocp_type: worker
    profile: "{{ compute }}"
  - name: "{{ metadata.infraID }}-worker1"
    ocp_type: worker
    profile: "{{ compute }}"
  - name: "{{ metadata.infraID }}-worker2"
    ocp_type: worker
    profile: "{{ compute }}"
```



IMPORTANT

Enter values for parameters whose descriptions begin with "Enter." Otherwise, you can use the default value or replace it with a new value.

General section

- **ovirt_cluster**: Enter the name of an existing RHV cluster in which to install the OpenShift Container Platform cluster.

- **ocp.assets_dir**: The path of a directory the **openshift-install** installation program creates to store the files that it generates.
- **ocp.ovirt_config_path**: The path of the **ovirt-config.yaml** file the installation program generates, for example, **./wrk/install-config.yaml**. This file contains the credentials required to interact with the REST API of the Manager.

Red Hat Enterprise Linux CoreOS (RHCOS) section

- **image_url**: Enter the URL of the RHCOS image you specified for download.
- **local_cmp_image_path**: The path of a local download directory for the compressed RHCOS image.
- **local_image_path**: The path of a local directory for the extracted RHCOS image.

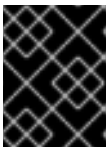
Profiles section

This section consists of two profiles:

- **control_plane**: The profile of the bootstrap and control plane nodes.
- **compute**: The profile of workers nodes in the compute plane.

These profiles have the following parameters. The default values of the parameters meet the minimum requirements for running a production cluster. You can increase or customize these values to meet your workload requirements.

- **cluster**: The value gets the cluster name from **ovirt_cluster** in the General Section.
- **memory**: The amount of memory, in GB, for the virtual machine.
- **sockets**: The number of sockets for the virtual machine.
- **cores**: The number of cores for the virtual machine.
- **template**: The name of the virtual machine template. If plan to install multiple clusters, and these clusters use templates that contain different specifications, prepend the template name with the ID of the cluster.
- **operating_system**: The type of guest operating system in the virtual machine. With oVirt/RHV version 4.4, this value must be **rhcos_x64** so the value of **Ignition script** can be passed to the VM.
- **type**: Enter **server** as the type of the virtual machine.



IMPORTANT

You must change the value of the **type** parameter from **high_performance** to **server**.

- **disks**: The disk specifications. The **control_plane** and **compute** nodes can have different storage domains.
- **size**: The minimum disk size.
- **name**: Enter the name of a disk connected to the target cluster in RHV.

- **interface**: Enter the interface type of the disk you specified.
- **storage_domain**: Enter the storage domain of the disk you specified.
- **nics**: Enter the **name** and **network** the virtual machines use. You can also specify the virtual network interface profile. By default, NICs obtain their MAC addresses from the oVirt/RHV MAC pool.

Virtual machines section

This final section, **vms**, defines the virtual machines you plan to create and deploy in the cluster. By default, it provides the minimum number of control plane and worker nodes for a production environment.

vms contains three required elements:

- **name**: The name of the virtual machine. In this case, **metadata.infraID** prepends the virtual machine name with the infrastructure ID from the **metadata.yml** file.
- **ocp_type**: The role of the virtual machine in the OpenShift Container Platform cluster. Possible values are **bootstrap**, **master**, **worker**.
- **profile**: The name of the profile from which each virtual machine inherits specifications. Possible values in this example are **control_plane** or **compute**.
  You can override the value a virtual machine inherits from its profile. To do this, you add the name of the profile attribute to the virtual machine in **inventory.yml** and assign it an overriding value. To see an example of this, examine the **name: "{{ metadata.infraID }}-bootstrap"** virtual machine in the preceding **inventory.yml** example: It has a **type** attribute whose value, **server**, overrides the value of the **type** attribute this virtual machine would otherwise inherit from the **control_plane** profile.

Metadata variables

For virtual machines, **metadata.infraID** prepends the name of the virtual machine with the infrastructure ID from the **metadata.json** file you create when you build the Ignition files.

The playbooks use the following code to read **infraID** from the specific file located in the **ocp.assets_dir**.

```
---
- name: include metadata.json vars
  include_vars:
    file: "{{ ocp.assets_dir }}/metadata.json"
    name: metadata

  ...
```

20.4.12. Specifying the RHCOS image settings

Update the Red Hat Enterprise Linux CoreOS (RHCOS) image settings of the **inventory.yml** file. Later, when you run this file one of the playbooks, it downloads a compressed Red Hat Enterprise Linux CoreOS (RHCOS) image from the **image_url** URL to the **local_cmp_image_path** directory. The playbook then uncompresses the image to the **local_image_path** directory and uses it to create oVirt/RHV templates.

Procedure

1. Locate the RHCOS image download page for the version of OpenShift Container Platform you are installing, such as Index of /pub/openshift-v4/dependencies/rhcos/latest/latest.

2. From that download page, copy the URL of an OpenStack **qcow2** image, such as **https://mirror.openshift.com/pub/openshift-v4/dependencies/rhcos/4.11/latest/rhcos-openstack.x86_64.qcow2.gz**.

3. Edit the **inventory.yml** playbook you downloaded earlier. In it, paste the URL as the value for **image_url**. For example:

```
rhcos:
  "https://mirror.openshift.com/pub/openshift-v4/dependencies/rhcos/4.11/latest/rhcos-openstack.x86_64.qcow2.gz"
```

20.4.13. Creating the install config file

You create an installation configuration file by running the installation program, **openshift-install**, and responding to its prompts with information you specified or gathered earlier.

When you finish responding to the prompts, the installation program creates an initial version of the **install-config.yaml** file in the assets directory you specified earlier, for example, **./wrk/install-config.yaml**

The installation program also creates a file, **$HOME/.ovirt/ovirt-config.yaml**, that contains all the connection parameters that are required to reach the Manager and use its REST API.

NOTE: The installation process does not use values you supply for some parameters, such as **Internal API virtual IP** and **Ingress virtual IP**, because you have already configured them in your infrastructure DNS.

It also uses the values you supply for parameters in **inventory.yml**, like the ones for **oVirt cluster**, **oVirt storage**, and **oVirt network**. And uses a script to remove or replace these same values from **install-config.yaml** with the previously mentioned **virtual IPs**.

Procedure

1. Run the installation program:

```
$ openshift-install create install-config --dir $ASSETS_DIR
```

2. Respond to the installation program's prompts with information about your system.

Example output

```
? SSH Public Key /home/user/.ssh/id_dsa.pub
? Platform <ovirt>
? Engine FQDN[:PORT] [? for help] <engine.fqdn>
? Enter ovirt-engine username <ocpadmin@internal>
? Enter password <******>
? oVirt cluster <cluster>
? oVirt storage <storage>
? oVirt network <net>
? Internal API virtual IP <172.16.0.252>
? Ingress virtual IP <172.16.0.251>
```

```
? Base Domain <example.org>
? Cluster Name <ocp4>
? Pull Secret [? for help] <********>
```

```
? SSH Public Key /home/user/.ssh/id_dsa.pub
? Platform <ovirt>
? Engine FQDN[:PORT] [? for help] <engine.fqdn>
? Enter ovirt-engine username <ocpadmin@internal>
? Enter password <******>
? oVirt cluster <cluster>
? oVirt storage <storage>
? oVirt network <net>
? Internal API virtual IP <172.16.0.252>
? Ingress virtual IP <172.16.0.251>
? Base Domain <example.org>
? Cluster Name <ocp4>
? Pull Secret [? for help] <********>
```

For **Internal API virtual IP** and **Ingress virtual IP**, supply the IP addresses you specified when you configured the DNS service.

Together, the values you enter for the **oVirt cluster** and **Base Domain** prompts form the FQDN portion of URLs for the REST API and any applications you create, such as **https://api.ocp4.example.org:6443/** and **https://console-openshift-console.apps.ocp4.example.org**.

You can get the pull secret from the Red Hat OpenShift Cluster Manager .

20.4.14. Customizing install-config.yaml

Here, you use three Python scripts to override some of the installation program's default behaviors:

- By default, the installation program uses the machine API to create nodes. To override this default behavior, you set the number of compute nodes to zero replicas. Later, you use Ansible playbooks to create the compute nodes.
- By default, the installation program sets the IP range of the machine network for nodes. To override this default behavior, you set the IP range to match your infrastructure.
- By default, the installation program sets the platform to **ovirt**. However, installing a cluster on user-provisioned infrastructure is more similar to installing a cluster on bare metal. Therefore, you delete the ovirt platform section from **install-config.yaml** and change the platform to **none**. Instead, you use **inventory.yml** to specify all of the required settings.

NOTE

These snippets work with Python 3 and Python 2.

Procedure

1. Set the number of compute nodes to zero replicas:

```
$ python3 -c 'import os, yaml
path = "%s/install-config.yaml" % os.environ["ASSETS_DIR"]
conf = yaml.safe_load(open(path))
```

```
conf["compute"][0]["replicas"] = 0
open(path, "w").write(yaml.dump(conf, default_flow_style=False))'
```

2. Set the IP range of the machine network. For example, to set the range to **172.16.0.0/16**, enter:

```
$ python3 -c 'import os, yaml
path = "%s/install-config.yaml" % os.environ["ASSETS_DIR"]
conf = yaml.safe_load(open(path))
conf["networking"]["machineNetwork"][0]["cidr"] = "172.16.0.0/16"
open(path, "w").write(yaml.dump(conf, default_flow_style=False))'
```

3. Remove the **ovirt** section and change the platform to **none**:

```
$ python3 -c 'import os, yaml
path = "%s/install-config.yaml" % os.environ["ASSETS_DIR"]
conf = yaml.safe_load(open(path))
platform = conf["platform"]
del platform["ovirt"]
platform["none"] = {}
open(path, "w").write(yaml.dump(conf, default_flow_style=False))'
```

WARNING

Red Hat Virtualization does not currently support installation with user-provisioned infrastructure on the oVirt platform. Therefore, you must set the platform to **none**, allowing OpenShift Container Platform to identify each node as a bare-metal node and the cluster as a bare-metal cluster. This is the same as installing a cluster on any platform, and has the following limitations:

1. There will be no cluster provider so you must manually add each machine and there will be no node scaling capabilities.
2. The oVirt CSI driver will not be installed and there will be no CSI capabilities.

20.4.15. Generate manifest files

Use the installation program to generate a set of manifest files in the assets directory.

The command to generate the manifest files displays a warning message before it consumes the **install-config.yaml** file.

If you plan to reuse the **install-config.yaml** file, create a backup copy of it before you back it up before you generate the manifest files.

Procedure

1. Optional: Create a backup copy of the **install-config.yaml** file:

```
$ cp install-config.yaml install-config.yaml.backup
```

2. Generate a set of manifests in your assets directory:

```
$ openshift-install create manifests --dir $ASSETS_DIR
```

This command displays the following messages.

Example output

```
INFO Consuming Install Config from target directory
WARNING Making control-plane schedulable by setting MastersSchedulable to true for
Scheduler cluster settings
```

The command generates the following manifest files:

Example output

```
$ tree
.
└── wrk
    ├── manifests
    │   ├── 04-openshift-machine-config-operator.yaml
    │   ├── cluster-config.yaml
    │   ├── cluster-dns-02-config.yml
    │   ├── cluster-infrastructure-02-config.yml
    │   ├── cluster-ingress-02-config.yml
    │   ├── cluster-network-01-crd.yml
    │   ├── cluster-network-02-config.yml
    │   ├── cluster-proxy-01-config.yaml
    │   ├── cluster-scheduler-02-config.yml
    │   ├── cvo-overrides.yaml
    │   ├── etcd-ca-bundle-configmap.yaml
    │   ├── etcd-client-secret.yaml
    │   ├── etcd-host-service-endpoints.yaml
    │   ├── etcd-host-service.yaml
    │   ├── etcd-metric-client-secret.yaml
    │   ├── etcd-metric-serving-ca-configmap.yaml
    │   ├── etcd-metric-signer-secret.yaml
    │   ├── etcd-namespace.yaml
    │   ├── etcd-service.yaml
    │   ├── etcd-serving-ca-configmap.yaml
    │   ├── etcd-signer-secret.yaml
    │   ├── kube-cloud-config.yaml
    │   ├── kube-system-configmap-root-ca.yaml
    │   ├── machine-config-server-tls-secret.yaml
    │   └── openshift-config-secret-pull-secret.yaml
    └── openshift
        ├── 99_kubeadmin-password-secret.yaml
        ├── 99_openshift-cluster-api_master-user-data-secret.yaml
        ├── 99_openshift-cluster-api_worker-user-data-secret.yaml
        ├── 99_openshift-machineconfig_99-master-ssh.yaml
        ├── 99_openshift-machineconfig_99-worker-ssh.yaml
        └── openshift-install-manifests.yaml
```

Next steps

- Make control plane nodes non-schedulable.

20.4.16. Making control-plane nodes non-schedulable

Because you are manually creating and deploying the control plane machines, you must configure a manifest file to make the control plane nodes non-schedulable.

Procedure

1. To make the control plane nodes non-schedulable, enter:

```
$ python3 -c 'import os, yaml
path = "%s/manifests/cluster-scheduler-02-config.yml" % os.environ["ASSETS_DIR"]
data = yaml.safe_load(open(path))
data["spec"]["mastersSchedulable"] = False
open(path, "w").write(yaml.dump(data, default_flow_style=False))'
```

20.4.17. Building the Ignition files

To build the Ignition files from the manifest files you just generated and modified, you run the installation program. This action creates a Red Hat Enterprise Linux CoreOS (RHCOS) machine, **initramfs**, which fetches the Ignition files and performs the configurations needed to create a node.

In addition to the Ignition files, the installation program generates the following:

- An **auth** directory that contains the admin credentials for connecting to the cluster with the **oc** and **kubectl** utilities.
- A **metadata.json** file that contains information such as the OpenShift Container Platform cluster name, cluster ID, and infrastructure ID for the current installation.

The Ansible playbooks for this installation process use the value of **infraID** as a prefix for the virtual machines they create. This prevents naming conflicts when there are multiple installations in the same oVirt/RHV cluster.

NOTE

Certificates in Ignition configuration files expire after 24 hours. Complete the cluster installation and keep the cluster running in a non-degraded state for 24 hours so that the first certificate rotation can finish.

Procedure

1. To build the Ignition files, enter:

```
$ openshift-install create ignition-configs --dir $ASSETS_DIR
```

Example output

```
$ tree
.
└── wrk
```

```
├── auth
│   ├── kubeadmin-password
│   └── kubeconfig
├── bootstrap.ign
├── master.ign
├── metadata.json
└── worker.ign
```

20.4.18. Creating templates and virtual machines

After confirming the variables in the **inventory.yml**, you run the first Ansible provisioning playbook, **create-templates-and-vms.yml**.

This playbook uses the connection parameters for the RHV Manager from **$HOME/.ovirt/ovirt-config.yaml** and reads **metadata.json** in the assets directory.

If a local Red Hat Enterprise Linux CoreOS (RHCOS) image is not already present, the playbook downloads one from the URL you specified for **image_url** in **inventory.yml**. It extracts the image and uploads it to RHV to create templates.

The playbook creates a template based on the **control_plane** and **compute** profiles in the **inventory.yml** file. If these profiles have different names, it creates two templates.

When the playbook finishes, the virtual machines it creates are stopped. You can get information from them to help configure other infrastructure elements. For example, you can get the virtual machines' MAC addresses to configure DHCP to assign permanent IP addresses to the virtual machines.

Procedure

1. In **inventory.yml**, under the **control_plane** and **compute** variables, change both instances of **type: high_performance** to **type: server**.
2. Optional: If you plan to perform multiple installations to the same cluster, create different templates for each OpenShift Container Platform installation. In the **inventory.yml** file, prepend the value of **template** with **infraID**. For example:

```
control_plane:
  cluster: "{{ ovirt_cluster }}"
  memory: 16GiB
  sockets: 4
  cores: 1
  template: "{{ metadata.infraID }}-rhcos_tpl"
  operating_system: "rhcos_x64"
  ...
```

3. Create the templates and virtual machines:

```
$ ansible-playbook -i inventory.yml create-templates-and-vms.yml
```

20.4.19. Creating the bootstrap machine

You create a bootstrap machine by running the **bootstrap.yml** playbook. This playbook starts the bootstrap virtual machine, and passes it the **bootstrap.ign** Ignition file from the assets directory. The bootstrap node configures itself so it can serve Ignition files to the control plane nodes.

To monitor the bootstrap process, you use the console in the RHV Administration Portal or connect to the virtual machine by using SSH.

Procedure

1. Create the bootstrap machine:

```
$ ansible-playbook -i inventory.yml bootstrap.yml
```

2. Connect to the bootstrap machine using a console in the Administration Portal or SSH. Replace **<bootstrap_ip>** with the bootstrap node IP address. To use SSH, enter:

```
$ ssh core@<boostrap.ip>
```

3. Collect **bootkube.service** journald unit logs for the release image service from the bootstrap node:

```
[core@ocp4-lk6b4-bootstrap ~]$ journalctl -b -f -u release-image.service -u bootkube.service
```

NOTE

The **bootkube.service** log on the bootstrap node outputs etcd **connection refused** errors, indicating that the bootstrap server is unable to connect to etcd on control plane nodes. After etcd has started on each control plane node and the nodes have joined the cluster, the errors should stop.

20.4.20. Creating the control plane nodes

You create the control plane nodes by running the **masters.yml** playbook. This playbook passes the **master.ign** Ignition file to each of the virtual machines. The Ignition file contains a directive for the control plane node to get the Ignition from a URL such as **https://api-int.ocp4.example.org:22623/config/master**. The port number in this URL is managed by the load balancer, and is accessible only inside the cluster.

Procedure

1. Create the control plane nodes:

```
$ ansible-playbook -i inventory.yml masters.yml
```

2. While the playbook creates your control plane, monitor the bootstrapping process:

```
$ openshift-install wait-for bootstrap-complete --dir $ASSETS_DIR
```

Example output

```
INFO API v1.24.0 up
INFO Waiting up to 40m0s for bootstrapping to complete...
```

3. When all the pods on the control plane nodes and etcd are up and running, the installation program displays the following output.

Example output

```
INFO It is now safe to remove the bootstrap resources
```

20.4.21. Verifying cluster status

You can verify your OpenShift Container Platform cluster's status during or after installation.

Procedure

1. In the cluster environment, export the administrator's kubeconfig file:

```
$ export KUBECONFIG=$ASSETS_DIR/auth/kubeconfig
```

   The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server.

2. View the control plane and compute machines created after a deployment:

```
$ oc get nodes
```

3. View your cluster's version:

```
$ oc get clusterversion
```

4. View your Operators' status:

```
$ oc get clusteroperator
```

5. View all running pods in the cluster:

```
$ oc get pods -A
```

20.4.22. Removing the bootstrap machine

After the **wait-for** command shows that the bootstrap process is complete, you must remove the bootstrap virtual machine to free up compute, memory, and storage resources. Also, remove settings for the bootstrap machine from the load balancer directives.

Procedure

1. To remove the bootstrap machine from the cluster, enter:

```
$ ansible-playbook -i inventory.yml retire-bootstrap.yml
```

2. Remove settings for the bootstrap machine from the load balancer directives.

20.4.23. Creating the worker nodes and completing the installation

Creating worker nodes is similar to creating control plane nodes. However, worker nodes workers do not automatically join the cluster. To add them to the cluster, you review and approve the workers' pending CSRs (Certificate Signing Requests).

After approving the first requests, you continue approving CSR until all of the worker nodes are approved. When you complete this process, the worker nodes become **Ready** and can have pods scheduled to run on them.

Finally, monitor the command line to see when the installation process completes.

Procedure

1. Create the worker nodes:

```
$ ansible-playbook -i inventory.yml workers.yml
```

2. To list all of the CSRs, enter:

```
$ oc get csr -A
```

   Eventually, this command displays one CSR per node. For example:

   Example output

```
NAME        AGE    SIGNERNAME                                    REQUESTOR
CONDITION
csr-2lnxd   63m    kubernetes.io/kubelet-serving                 system:node:ocp4-lk6b4-
master0.ocp4.example.org                                         Approved,Issued
csr-hff4q   64m    kubernetes.io/kube-apiserver-client-kubelet
system:serviceaccount:openshift-machine-config-operator:node-bootstrapper
Approved,Issued
csr-hsn96   60m    kubernetes.io/kubelet-serving                 system:node:ocp4-lk6b4-
master2.ocp4.example.org                                         Approved,Issued
csr-m724n   6m2s   kubernetes.io/kube-apiserver-client-kubelet
system:serviceaccount:openshift-machine-config-operator:node-bootstrapper   Pending
csr-p4dz2   60m    kubernetes.io/kube-apiserver-client-kubelet
system:serviceaccount:openshift-machine-config-operator:node-bootstrapper
Approved,Issued
csr-t9vfj   60m    kubernetes.io/kubelet-serving                 system:node:ocp4-lk6b4-
master1.ocp4.example.org                                         Approved,Issued
csr-tggtr   61m    kubernetes.io/kube-apiserver-client-kubelet
system:serviceaccount:openshift-machine-config-operator:node-bootstrapper
Approved,Issued
csr-wcbrf   7m6s   kubernetes.io/kube-apiserver-client-kubelet
system:serviceaccount:openshift-machine-config-operator:node-bootstrapper   Pending
```

3. To filter the list and see only pending CSRs, enter:

```
$ watch "oc get csr -A | grep pending -i"
```

   This command refreshes the output every two seconds and displays only pending CSRs. For example:

   Example output

```
Every 2.0s: oc get csr -A | grep pending -i

csr-m724n   10m   kubernetes.io/kube-apiserver-client-kubelet
system:serviceaccount:openshift-machine-config-operator:node-bootstrapper   Pending
csr-wcbrf   11m   kubernetes.io/kube-apiserver-client-kubelet
system:serviceaccount:openshift-machine-config-operator:node-bootstrapper   Pending
```

4. Inspect each pending request. For example:

Example output

```
$ oc describe csr csr-m724n
```

Example output

```
Name:               csr-m724n
Labels:             <none>
Annotations:        <none>
CreationTimestamp:  Sun, 19 Jul 2020 15:59:37 +0200
Requesting User:    system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper
Signer:             kubernetes.io/kube-apiserver-client-kubelet
Status:             Pending
Subject:
        Common Name:    system:node:ocp4-lk6b4-worker1.ocp4.example.org
        Serial Number:
        Organization:   system:nodes
Events:  <none>
```

5. If the CSR information is correct, approve the request:

```
$ oc adm certificate approve csr-m724n
```

6. Wait for the installation process to finish:

```
$ openshift-install wait-for install-complete --dir $ASSETS_DIR --log-level debug
```

When the installation completes, the command line displays the URL of the OpenShift Container Platform web console and the administrator user name and password.

20.4.24. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.11, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to OpenShift Cluster Manager Hybrid Cloud Console.

After you confirm that your OpenShift Cluster Manager Hybrid Cloud Console inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, use subscription watch to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

Additional resources

- See About remote health monitoring for more information about the Telemetry service

20.5. INSTALLING A CLUSTER ON RHV IN A RESTRICTED NETWORK

In OpenShift Container Platform version 4.11, you can install a customized OpenShift Container Platform cluster on Red Hat Virtualization (RHV) in a restricted network by creating an internal mirror of the installation release content.

20.5.1. Prerequisites

The following items are required to install an OpenShift Container Platform cluster on a RHV environment.

- You reviewed details about the OpenShift Container Platform installation and update processes.
- You read the documentation on selecting a cluster installation method and preparing it for users.
- You have a supported combination of versions in the Support Matrix for OpenShift Container Platform on RHV.
- You created a registry on your mirror host and obtained the **imageContentSources** data for your version of OpenShift Container Platform.

IMPORTANT

Because the installation media is on the mirror host, you can use that computer to complete all installation steps.

- You provisioned persistent storage for your cluster. To deploy a private image registry, your storage must provide ReadWriteMany access modes.
- If you use a firewall and plan to use the Telemetry service, you configured the firewall to allow the sites that your cluster requires access to.

NOTE

Be sure to also review this site list if you are configuring a proxy.

20.5.2. About installations in restricted networks

In OpenShift Container Platform 4.11, you can perform an installation that does not require an active connection to the internet to obtain software components. Restricted network installations can be completed using installer-provisioned infrastructure or user-provisioned infrastructure, depending on the cloud platform to which you are installing the cluster.

If you choose to perform a restricted network installation on a cloud platform, you still require access to its cloud APIs. Some cloud functions, like Amazon Web Service's Route 53 DNS and IAM services, require internet access. Depending on your network, you might require less internet access for an installation on bare metal hardware or on VMware vSphere.

To complete a restricted network installation, you must create a registry that mirrors the contents of the OpenShift image registry and contains the installation media. You can create this registry on a mirror

host, which can access both the internet and your closed network, or by using other methods that meet your restrictions.

20.5.2.1. Additional limits

Clusters in restricted networks have the following additional limitations and restrictions:

- The **ClusterVersion** status includes an **Unable to retrieve available updates** error.
- By default, you cannot use the contents of the Developer Catalog because you cannot access the required image stream tags.

20.5.3. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.11, you require access to the internet to obtain the images that are necessary to install your cluster.

You must have internet access to:

- Access OpenShift Cluster Manager Hybrid Cloud Console to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access Quay.io to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.

IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

20.5.4. Requirements for the RHV environment

To install and run an OpenShift Container Platform version 4.11 cluster, the RHV environment must meet the following requirements.

Not meeting these requirements can cause the installation or process to fail. Additionally, not meeting these requirements can cause the OpenShift Container Platform cluster to fail days or weeks after installation.

The following requirements for CPU, memory, and storage resources are based on **default** values multiplied by the default number of virtual machines the installation program creates. These resources must be available **in addition to** what the RHV environment uses for non-OpenShift Container Platform operations.

By default, the installation program creates seven virtual machines during the installation process. First, it creates a bootstrap virtual machine to provide temporary services and a control plane while it creates the rest of the OpenShift Container Platform cluster. When the installation program finishes creating the cluster, deleting the bootstrap machine frees up its resources.

If you increase the number of virtual machines in the RHV environment, you must increase the resources accordingly.

Requirements

- The RHV version is 4.4.
- The RHV environment has one data center whose state is **Up**.
- The RHV data center contains an RHV cluster.
- The RHV cluster has the following resources exclusively for the OpenShift Container Platform cluster:
  - Minimum 28 vCPUs: four for each of the seven virtual machines created during installation.
  - 112 GiB RAM or more, including:
    - 16 GiB or more for the bootstrap machine, which provides the temporary control plane.
    - 16 GiB or more for each of the three control plane machines which provide the control plane.
    - 16 GiB or more for each of the three compute machines, which run the application workloads.
- The RHV storage domain must meet these etcd backend performance requirements.
- In production environments, each virtual machine must have 120 GiB or more. Therefore, the storage domain must provide 840 GiB or more for the default OpenShift Container Platform cluster. In resource-constrained or non-production environments, each virtual machine must have 32 GiB or more, so the storage domain must have 230 GiB or more for the default OpenShift Container Platform cluster.
- To download images from the Red Hat Ecosystem Catalog during installation and update procedures, the RHV cluster must have access to an internet connection. The Telemetry service also needs an internet connection to simplify the subscription and entitlement process.
- The RHV cluster must have a virtual network with access to the REST API on the RHV Manager. Ensure that DHCP is enabled on this network, because the VMs that the installer creates obtain their IP address by using DHCP.
- A user account and group with the following least privileges for installing and managing an OpenShift Container Platform cluster on the target RHV cluster:
  - **DiskOperator**
  - **DiskCreator**
  - **UserTemplateBasedVm**
  - **TemplateOwner**
  - **TemplateCreator**
  - **ClusterAdmin** on the target cluster

WARNING

Apply the principle of least privilege: Avoid using an administrator account with **SuperUser** privileges on RHV during the installation process. The installation program saves the credentials you provide to a temporary **ovirt-config.yaml** file that might be compromised.

20.5.5. Verifying the requirements for the RHV environment

Verify that the RHV environment meets the requirements to install and run an OpenShift Container Platform cluster. Not meeting these requirements can cause failures.

IMPORTANT

These requirements are based on the default resources the installation program uses to create control plane and compute machines. These resources include vCPUs, memory, and storage. If you change these resources or increase the number of OpenShift Container Platform machines, adjust these requirements accordingly.

Procedure

1. Check that the RHV version supports installation of OpenShift Container Platform version 4.11.
   a. In the RHV Administration Portal, click the **?** help icon in the upper-right corner and select **About**.
   b. In the window that opens, make a note of the **RHV Software Version**
   c. Confirm that the RHV version is 4.4. For more information about supported version combinations, see Support Matrix for OpenShift Container Platform on RHV .
2. Inspect the data center, cluster, and storage.
   a. In the RHV Administration Portal, click **Compute → Data Centers**.
   b. Confirm that the data center where you plan to install OpenShift Container Platform is accessible.
   c. Click the name of that data center.
   d. In the data center details, on the **Storage** tab, confirm the storage domain where you plan to install OpenShift Container Platform is **Active**.
   e. Record the **Domain Name** for use later on.
   f. Confirm **Free Space** has at least 230 GiB.
   g. Confirm that the storage domain meets these etcd backend performance requirements, which you can measure by using the fio performance benchmarking tool .
   h. In the data center details, click the **Clusters** tab.

i. Find the RHV cluster where you plan to install OpenShift Container Platform. Record the cluster name for use later on.

3. Inspect the RHV host resources.

   a. In the RHV Administration Portal, click **Compute > Clusters**.

   b. Click the cluster where you plan to install OpenShift Container Platform.

   c. In the cluster details, click the **Hosts** tab.

   d. Inspect the hosts and confirm they have a combined total of at least 28 **Logical CPU Cores** available *exclusively* for the OpenShift Container Platform cluster.

   e. Record the number of available **Logical CPU Cores** for use later on.

   f. Confirm that these CPU cores are distributed so that each of the seven virtual machines created during installation can have four cores.

   g. Confirm that, all together, the hosts have 112 GiB of **Max free Memory for scheduling new virtual machines** distributed to meet the requirements for each of the following OpenShift Container Platform machines:

      - 16 GiB required for the bootstrap machine
      - 16 GiB required for each of the three control plane machines
      - 16 GiB for each of the three compute machines

   h. Record the amount of **Max free Memory for scheduling new virtual machines** for use later on.

4. Verify that the virtual network for installing OpenShift Container Platform has access to the RHV Manager's REST API. From a virtual machine on this network, use curl to reach the RHV Manager's REST API:

```
$ curl -k -u <username>@<profile>:<password> \ 1
https://<engine-fqdn>/ovirt-engine/api 2
```

1 For **<username>**, specify the user name of an RHV account with privileges to create and manage an OpenShift Container Platform cluster on RHV. For **<profile>**, specify the login profile, which you can get by going to the RHV Administration Portal login page and reviewing the **Profile** dropdown list. For **<password>**, specify the password for that user name.

2 For **<engine-fqdn>**, specify the fully qualified domain name of the RHV environment.

For example:

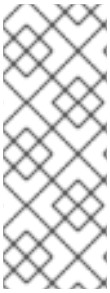
```
$ curl -k -u ocpadmin@internal:pw123 \
https://rhv-env.virtlab.example.com/ovirt-engine/api
```

20.5.6. Networking requirements for user-provisioned infrastructure

All the Red Hat Enterprise Linux CoreOS (RHCOS) machines require networking to be configured in **initramfs** during boot to fetch their Ignition config files.

During the initial boot, the machines require an IP address configuration that is set either through a DHCP server or statically by providing the required boot options. After a network connection is established, the machines download their Ignition config files from an HTTP or HTTPS server. The Ignition config files are then used to set the exact state of each machine. The Machine Config Operator completes more changes to the machines, such as the application of new certificates or keys, after installation.

It is recommended to use a DHCP server for long-term management of the cluster machines. Ensure that the DHCP server is configured to provide persistent IP addresses, DNS server information, and hostnames to the cluster machines.



NOTE

If a DHCP service is not available for your user-provisioned infrastructure, you can instead provide the IP networking configuration and the address of the DNS server to the nodes at RHCOS install time. These can be passed as boot arguments if you are installing from an ISO image. See the *Installing RHCOS and starting the OpenShift Container Platform bootstrap process* section for more information about static IP provisioning and advanced networking options.

The Kubernetes API server must be able to resolve the node names of the cluster machines. If the API servers and worker nodes are in different zones, you can configure a default DNS search zone to allow the API server to resolve the node names. Another supported approach is to always refer to hosts by their fully-qualified domain names in both the node objects and all DNS requests.

Firewall

Configure your firewall so your cluster has access to required sites.

See also:

- Red Hat Virtualization Manager firewall requirements
- Host firewall requirements

DNS

Configure infrastructure-provided DNS to allow the correct resolution of the main components and services. If you use only one load balancer, these DNS records can point to the same IP address.

- Create DNS records for **api.<cluster_name>.<base_domain>** (internal and external resolution) and **api-int.<cluster_name>.<base_domain>** (internal resolution) that point to the load balancer for the control plane machines.
- Create a DNS record for ***.apps.<cluster_name>.<base_domain>** that points to the load balancer for the Ingress router. For example, ports **443** and **80** of the compute machines.

20.5.6.1. Setting the cluster node hostnames through DHCP

On Red Hat Enterprise Linux CoreOS (RHCOS) machines, the hostname is set through NetworkManager. By default, the machines obtain their hostname through DHCP. If the hostname is not provided by DHCP, set statically through kernel arguments, or another method, it is obtained through a

reverse DNS lookup. Reverse DNS lookup occurs after the network has been initialized on a node and can take time to resolve. Other system services can start prior to this and detect the hostname as **localhost** or similar. You can avoid this by using DHCP to provide the hostname for each cluster node.

Additionally, setting the hostnames through DHCP can bypass any manual DNS record name configuration errors in environments that have a DNS split-horizon implementation.

20.5.6.2. Network connectivity requirements

You must configure the network connectivity between machines to allow OpenShift Container Platform cluster components to communicate. Each machine must be able to resolve the hostnames of all other machines in the cluster.

This section provides details about the ports that are required.

IMPORTANT

In connected OpenShift Container Platform environments, all nodes are required to have internet access to pull images for platform containers and provide telemetry data to Red Hat.

Table 20.9. Ports used for all-machine to all-machine communications

Protocol	Port	Description
ICMP	N/A	Network reachability tests
TCP	**1936**	Metrics
	9000-**9999**	Host level services, including the node exporter on ports **9100**-**9101** and the Cluster Version Operator on port**9099**.
	10250-**10259**	The default ports that Kubernetes reserves
	10256	openshift-sdn
UDP	**4789**	VXLAN
	6081	Geneve
	9000-**9999**	Host level services, including the node exporter on ports **9100**-**9101**.
	500	IPsec IKE packets
	4500	IPsec NAT-T packets
TCP/UDP	**30000**-**32767**	Kubernetes node port
ESP	N/A	IPsec Encapsulating Security Payload (ESP)

Table 20.10. Ports used for all-machine to control plane communications

Protocol	Port	Description
TCP	**6443**	Kubernetes API

Table 20.11. Ports used for control plane machine to control plane machine communications

Protocol	Port	Description
TCP	**2379-2380**	etcd server and peer ports

NTP configuration for user-provisioned infrastructure
OpenShift Container Platform clusters are configured to use a public Network Time Protocol (NTP) server by default. If you want to use a local enterprise NTP server, or if your cluster is being deployed in a disconnected network, you can configure the cluster to use a specific time server. For more information, see the documentation for *Configuring chrony time service* .

If a DHCP server provides NTP server information, the chrony time service on the Red Hat Enterprise Linux CoreOS (RHCOS) machines read the information and can sync the clock with the NTP servers.

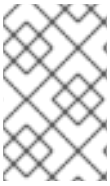
20.5.7. User-provisioned DNS requirements

In OpenShift Container Platform deployments, DNS name resolution is required for the following components:

- The Kubernetes API
- The OpenShift Container Platform application wildcard
- The bootstrap, control plane, and compute machines

Reverse DNS resolution is also required for the Kubernetes API, the bootstrap machine, the control plane machines, and the compute machines.

DNS A/AAAA or CNAME records are used for name resolution and PTR records are used for reverse name resolution. The reverse records are important because Red Hat Enterprise Linux CoreOS (RHCOS) uses the reverse records to set the hostnames for all the nodes, unless the hostnames are provided by DHCP. Additionally, the reverse records are used to generate the certificate signing requests (CSR) that OpenShift Container Platform needs to operate.



NOTE

It is recommended to use a DHCP server to provide the hostnames to each cluster node. See the *DHCP recommendations for user-provisioned infrastructure* section for more information.

The following DNS records are required for a user-provisioned OpenShift Container Platform cluster and they must be in place before installation. In each record, **<cluster_name>** is the cluster name and **<base_domain>** is the base domain that you specify in the **install-config.yaml** file. A complete DNS record takes the form: **<component>.<cluster_name>.<base_domain>.**.

Table 20.12. Required DNS records

Component	Record	Description
Kubernetes API	**api.<cluster_name>.<base_domain>.**	A DNS A/AAAA or CNAME record, and a DNS PTR record, to identify the API load balancer. These records must be resolvable by both clients external to the cluster and from all the nodes within the cluster.
	api-int.<cluster_name>.<base_domain>.	A DNS A/AAAA or CNAME record, and a DNS PTR record, to internally identify the API load balancer. These records must be resolvable from all the nodes within the cluster.  **IMPORTANT** The API server must be able to resolve the worker nodes by the hostnames that are recorded in Kubernetes. If the API server cannot resolve the node names, then proxied API calls can fail, and you cannot retrieve logs from pods.
Routes	***.apps.<cluster_name>.<base_domain>.**	A wildcard DNS A/AAAA or CNAME record that refers to the application ingress load balancer. The application ingress load balancer targets the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default. These records must be resolvable by both clients external to the cluster and from all the nodes within the cluster. For example, **console-openshift-console.apps.<cluster_name>.<base_domain>** is used as a wildcard route to the OpenShift Container Platform console.
Bootstrap machine	**bootstrap.<cluster_name>.<base_domain>.**	A DNS A/AAAA or CNAME record, and a DNS PTR record, to identify the bootstrap machine. These records must be resolvable by the nodes within the cluster.
Control plane machines	**<master><n>.<cluster_name>.<base_domain>.**	DNS A/AAAA or CNAME records and DNS PTR records to identify each machine for the control plane nodes. These records must be resolvable by the nodes within the cluster.
Compute machines	**<worker><n>.<cluster_name>.<base_domain>.**	DNS A/AAAA or CNAME records and DNS PTR records to identify each machine for the worker nodes. These records must be resolvable by the nodes within the cluster.

NOTE

In OpenShift Container Platform 4.4 and later, you do not need to specify etcd host and SRV records in your DNS configuration.

TIP

You can use the **dig** command to verify name and reverse name resolution. See the section on *Validating DNS resolution for user-provisioned infrastructure* for detailed validation steps.

20.5.7.1. Example DNS configuration for user-provisioned clusters

This section provides A and PTR record configuration samples that meet the DNS requirements for deploying OpenShift Container Platform on user-provisioned infrastructure. The samples are not meant to provide advice for choosing one DNS solution over another.

In the examples, the cluster name is **ocp4** and the base domain is **example.com**.

Example DNS A record configuration for a user-provisioned cluster

The following example is a BIND zone file that shows sample A records for name resolution in a user-provisioned cluster.

Example 20.1. Sample DNS zone database

```
$TTL 1W
@ IN SOA ns1.example.com. root (
  2019070700 ; serial
  3H  ; refresh (3 hours)
  30M  ; retry (30 minutes)
  2W  ; expiry (2 weeks)
  1W )  ; minimum (1 week)
 IN NS ns1.example.com.
 IN MX 10 smtp.example.com.
;
;
ns1.example.com.  IN A 192.168.1.5
smtp.example.com.  IN A 192.168.1.5
;
helper.example.com.  IN A 192.168.1.5
helper.ocp4.example.com. IN A 192.168.1.5
;
api.ocp4.example.com.  IN A 192.168.1.5 1
api-int.ocp4.example.com. IN A 192.168.1.5 2
;
*.apps.ocp4.example.com. IN A 192.168.1.5 3
;
bootstrap.ocp4.example.com. IN A 192.168.1.96 4
;
master0.ocp4.example.com. IN A 192.168.1.97 5
master1.ocp4.example.com. IN A 192.168.1.98 6
master2.ocp4.example.com. IN A 192.168.1.99 7
;
worker0.ocp4.example.com. IN A 192.168.1.11 8
```

```
worker1.ocp4.example.com. IN A 192.168.1.7 9
;
;EOF
```

1. Provides name resolution for the Kubernetes API. The record refers to the IP address of the API load balancer.
2. Provides name resolution for the Kubernetes API. The record refers to the IP address of the API load balancer and is used for internal cluster communications.
3. Provides name resolution for the wildcard routes. The record refers to the IP address of the application ingress load balancer. The application ingress load balancer targets the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.

NOTE

In the example, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

4. Provides name resolution for the bootstrap machine.
5. 6. 7. Provides name resolution for the control plane machines.
8. 9. Provides name resolution for the compute machines.

Example DNS PTR record configuration for a user-provisioned cluster

The following example BIND zone file shows sample PTR records for reverse name resolution in a user-provisioned cluster.

Example 20.2. Sample DNS zone database for reverse records

```
$TTL 1W
@ IN SOA ns1.example.com. root (
  2019070700 ; serial
  3H  ; refresh (3 hours)
  30M  ; retry (30 minutes)
  2W  ; expiry (2 weeks)
  1W )  ; minimum (1 week)
 IN NS ns1.example.com.
;
5.1.168.192.in-addr.arpa. IN PTR api.ocp4.example.com. 1
5.1.168.192.in-addr.arpa. IN PTR api-int.ocp4.example.com. 2
;
96.1.168.192.in-addr.arpa. IN PTR bootstrap.ocp4.example.com. 3
;
97.1.168.192.in-addr.arpa. IN PTR master0.ocp4.example.com. 4
98.1.168.192.in-addr.arpa. IN PTR master1.ocp4.example.com. 5
99.1.168.192.in-addr.arpa. IN PTR master2.ocp4.example.com. 6
```

```
;
11.1.168.192.in-addr.arpa. IN PTR worker0.ocp4.example.com. 7
7.1.168.192.in-addr.arpa. IN PTR worker1.ocp4.example.com. 8
;
;EOF
```

1 Provides reverse DNS resolution for the Kubernetes API. The PTR record refers to the record name of the API load balancer.

2 Provides reverse DNS resolution for the Kubernetes API. The PTR record refers to the record name of the API load balancer and is used for internal cluster communications.

3 Provides reverse DNS resolution for the bootstrap machine.

4 5 6 Provides reverse DNS resolution for the control plane machines.

7 8 Provides reverse DNS resolution for the compute machines.

NOTE

A PTR record is not required for the OpenShift Container Platform application wildcard.

20.5.7.2. Load balancing requirements for user-provisioned infrastructure

Before you install OpenShift Container Platform, you must provision the API and application ingress load balancing infrastructure. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

NOTE

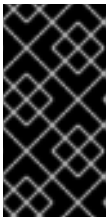
If you want to deploy the API and application Ingress load balancers with a Red Hat Enterprise Linux (RHEL) instance, you must purchase the RHEL subscription separately.

The load balancing infrastructure must meet the following requirements:

1. **API load balancer**: Provides a common endpoint for users, both human and machine, to interact with and configure the platform. Configure the following conditions:

   - Layer 4 load balancing only. This can be referred to as Raw TCP, SSL Passthrough, or SSL Bridge mode. If you use SSL Bridge mode, you must enable Server Name Indication (SNI) for the API routes.

   - A stateless load balancing algorithm. The options vary based on the load balancer implementation.



IMPORTANT

Do not configure session persistence for an API load balancer. Configuring session persistence for a Kubernetes API server might cause performance issues from excess application traffic for your OpenShift Container Platform cluster and the Kubernetes API that runs inside the cluster.

Configure the following ports on both the front and back of the load balancers:

Table 20.13. API load balancer

Port	Back-end machines (pool members)	Internal	External	Description
6443	Bootstrap and control plane. You remove the bootstrap machine from the load balancer after the bootstrap machine initializes the cluster control plane. You must configure the **/readyz** endpoint for the API server health check probe.	X	X	Kubernetes API server
22623	Bootstrap and control plane. You remove the bootstrap machine from the load balancer after the bootstrap machine initializes the cluster control plane.	X		Machine config server

NOTE

The load balancer must be configured to take a maximum of 30 seconds from the time the API server turns off the **/readyz** endpoint to the removal of the API server instance from the pool. Within the time frame after **/readyz** returns an error or becomes healthy, the endpoint must have been removed or added. Probing every 5 or 10 seconds, with two successful requests to become healthy and three to become unhealthy, are well-tested values.

2. **Application Ingress load balancer**: Provides an ingress point for application traffic flowing in from outside the cluster. A working configuration for the Ingress router is required for an OpenShift Container Platform cluster.
Configure the following conditions:

   - Layer 4 load balancing only. This can be referred to as Raw TCP, SSL Passthrough, or SSL Bridge mode. If you use SSL Bridge mode, you must enable Server Name Indication (SNI) for the ingress routes.
   - A connection-based or session-based persistence is recommended, based on the options available and types of applications that will be hosted on the platform.

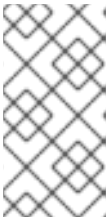
TIP

If the true IP address of the client can be seen by the application Ingress load balancer, enabling source IP-based session persistence can improve performance for applications that use end-to-end TLS encryption.

Configure the following ports on both the front and back of the load balancers:

Table 20.14. Application Ingress load balancer

Port	Back-end machines (pool members)	Internal	External	Description
443	The machines that run the Ingress Controller pods, compute, or worker, by default.	X	X	HTTPS traffic
80	The machines that run the Ingress Controller pods, compute, or worker, by default.	X	X	HTTP traffic



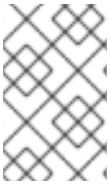
NOTE

If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application Ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes.

20.5.7.2.1. Example load balancer configuration for user-provisioned clusters

This section provides an example API and application ingress load balancer configuration that meets the load balancing requirements for user-provisioned clusters. The sample is an **/etc/haproxy/haproxy.cfg** configuration for an HAProxy load balancer. The example is not meant to provide advice for choosing one load balancing solution over another.

In the example, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.



NOTE

If you are using HAProxy as a load balancer and SELinux is set to **enforcing**, you must ensure that the HAProxy service can bind to the configured TCP port by running **setsebool -P haproxy_connect_any=1**.

Example 20.3. Sample API and application Ingress load balancer configuration

```
global
  log         127.0.0.1 local2
  pidfile     /var/run/haproxy.pid
  maxconn     4000
  daemon
defaults
  mode                    http
  log                     global
  option                  dontlognull
  option http-server-close
  option                  redispatch
  retries                 3
  timeout http-request    10s
  timeout queue           1m
  timeout connect         10s
  timeout client          1m
```

```
  timeout server          1m
  timeout http-keep-alive 10s
  timeout check           10s
  maxconn                 3000
listen api-server-6443 (1)
  bind *:6443
  mode tcp
  server bootstrap bootstrap.ocp4.example.com:6443 check inter 1s backup (2)
  server master0 master0.ocp4.example.com:6443 check inter 1s
  server master1 master1.ocp4.example.com:6443 check inter 1s
  server master2 master2.ocp4.example.com:6443 check inter 1s
listen machine-config-server-22623 (3)
  bind *:22623
  mode tcp
  option  httpchk GET /readyz HTTP/1.0
  option  log-health-checks
  balance roundrobin
  server bootstrap bootstrap.ocp4.example.com:6443 verify none check check-ssl inter 10s fall 2
rise 3 backup (4)
  server master0 master0.ocp4.example.com:6443 weight 1 verify none check check-ssl inter 10s
fall 2 rise 3
  server master1 master1.ocp4.example.com:6443 weight 1 verify none check check-ssl inter 10s
fall 2 rise 3
  server master2 master2.ocp4.example.com:6443 weight 1 verify none check check-ssl inter 10s
fall 2 rise 3
listen ingress-router-443 (5)
  bind *:443
  mode tcp
  balance source
  server worker0 worker0.ocp4.example.com:443 check inter 1s
  server worker1 worker1.ocp4.example.com:443 check inter 1s
listen ingress-router-80 (6)
  bind *:80
  mode tcp
  balance source
  server worker0 worker0.ocp4.example.com:80 check inter 1s
  server worker1 worker1.ocp4.example.com:80 check inter 1s
```

(1) Port **6443** handles the Kubernetes API traffic and points to the control plane machines.

(2) (4) The bootstrap entries must be in place before the OpenShift Container Platform cluster installation and they must be removed after the bootstrap process is complete.

(3) Port **22623** handles the machine config server traffic and points to the control plane machines.

(5) Port **443** handles the HTTPS traffic and points to the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.

(6) Port **80** handles the HTTP traffic and points to the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.

NOTE

If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application Ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes.

TIP

If you are using HAProxy as a load balancer, you can check that the **haproxy** process is listening on ports **6443**, **22623**, **443**, and **80** by running **netstat -nltupe** on the HAProxy node.

20.5.8. Setting up the installation machine

To run the binary **openshift-install** installation program and Ansible scripts, set up the RHV Manager or an Red Hat Enterprise Linux (RHEL) computer with network access to the RHV environment and the REST API on the Manager.

Procedure

1. Update or install Python3 and Ansible. For example:

```
# dnf update python3 ansible
```

2. Install the **python3-ovirt-engine-sdk4** package to get the Python Software Development Kit.

3. Install the **ovirt.image-template** Ansible role. On the RHV Manager and other Red Hat Enterprise Linux (RHEL) machines, this role is distributed as the **ovirt-ansible-image-template** package. For example, enter:

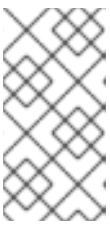
```
# dnf install ovirt-ansible-image-template
```

4. Install the **ovirt.vm-infra** Ansible role. On the RHV Manager and other RHEL machines, this role is distributed as the **ovirt-ansible-vm-infra** package.

```
# dnf install ovirt-ansible-vm-infra
```

5. Create an environment variable and assign an absolute or relative path to it. For example, enter:

```
$ export ASSETS_DIR=./wrk
```



NOTE

The installation program uses this variable to create a directory where it saves important installation-related files. Later, the installation process reuses this variable to locate those asset files. Avoid deleting this assets directory; it is required for uninstalling the cluster.

20.5.9. Setting up the CA certificate for RHV

Download the CA certificate from the Red Hat Virtualization (RHV) Manager and set it up on the installation machine.

You can download the certificate from a webpage on the RHV Manager or by using a **curl** command.

Later, you provide the certificate to the installation program.

Procedure

1. Use either of these two methods to download the CA certificate:
   - Go to the Manager's webpage, **https://<engine-fqdn>/ovirt-engine/**. Then, under **Downloads**, click the **CA Certificate** link.
   - Run the following command:

     ```
     $ curl -k 'https://<engine-fqdn>/ovirt-engine/services/pki-resource?resource=ca-certificate&format=X509-PEM-CA' -o /tmp/ca.pem
     ```
     (1)

     (1) For **<engine-fqdn>**, specify the fully qualified domain name of the RHV Manager, such as **rhv-env.virtlab.example.com**.

2. Configure the CA file to grant rootless user access to the Manager. Set the CA file permissions to have an octal value of **0644** (symbolic value: **-rw-r—r--**):

   ```
   $ sudo chmod 0644 /tmp/ca.pem
   ```

3. For Linux, copy the CA certificate to the directory for server certificates. Use **-p** to preserve the permissions:

   ```
   $ sudo cp -p /tmp/ca.pem /etc/pki/ca-trust/source/anchors/ca.pem
   ```

4. Add the certificate to the certificate manager for your operating system:
   - For macOS, double-click the certificate file and use the **Keychain Access** utility to add the file to the **System** keychain.
   - For Linux, update the CA trust:

     ```
     $ sudo update-ca-trust
     ```

     NOTE

     If you use your own certificate authority, make sure the system trusts it.

Additional resources

- To learn more, see Authentication and Security in the RHV documentation.

20.5.10. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes

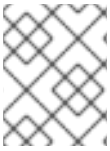
through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the ~/**.ssh/authorized_keys** list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The **./openshift-install gather** command also requires the SSH public key to be in place on the cluster nodes.

IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.



NOTE

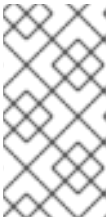
You must use a local key, not one that you configured with platform-specific approaches such as AWS key pairs.

Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N '' -f <path>/<file_name> 1
```

1 Specify the path and file name, such as ~/**.ssh/id_ed25519**, of the new SSH key. If you have an existing key pair, ensure your public key is in the your ~/**.ssh** directory.



NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS validated or Modules In Process cryptographic libraries on the **x86_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

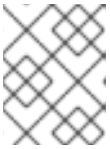
2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the ~/**.ssh/id_ed25519.pub** public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the **./openshift-install gather** command.



NOTE

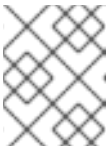
On some distributions, default SSH private key identities such as ~/**.ssh/id_rsa** and ~/**.ssh/id_dsa** are managed automatically.

a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

Example output

```
Agent pid 31874
```



NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

1 Specify the path and file name for your SSH private key, such as ~/**.ssh/id_ed25519**

Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

20.5.11. Downloading the Ansible playbooks

Download the Ansible playbooks for installing OpenShift Container Platform version 4.11 on RHV.

Procedure

- On your installation machine, run the following commands:

```
$ mkdir playbooks
```

```
$ cd playbooks
```

```
$  xargs -n 1 curl -O <<< '
      https://raw.githubusercontent.com/openshift/installer/release-4.11/upi/ovirt/bootstrap.yml
      https://raw.githubusercontent.com/openshift/installer/release-4.11/upi/ovirt/common-
auth.yml
```

```
    https://raw.githubusercontent.com/openshift/installer/release-4.11/upi/ovirt/create-
templates-and-vms.yml
    https://raw.githubusercontent.com/openshift/installer/release-4.11/upi/ovirt/inventory.yml
    https://raw.githubusercontent.com/openshift/installer/release-4.11/upi/ovirt/masters.yml
    https://raw.githubusercontent.com/openshift/installer/release-4.11/upi/ovirt/retire-
bootstrap.yml
    https://raw.githubusercontent.com/openshift/installer/release-4.11/upi/ovirt/retire-
masters.yml
    https://raw.githubusercontent.com/openshift/installer/release-4.11/upi/ovirt/retire-
workers.yml
    https://raw.githubusercontent.com/openshift/installer/release-4.11/upi/ovirt/workers.yml'
```

Next steps

- After you download these Ansible playbooks, you must also create the environment variable for the assets directory and customize the **inventory.yml** file before you create an installation configuration file by running the installation program.

20.5.12. The inventory.yml file

You use the **inventory.yml** file to define and create elements of the OpenShift Container Platform cluster you are installing. This includes elements such as the Red Hat Enterprise Linux CoreOS (RHCOS) image, virtual machine templates, bootstrap machine, control plane nodes, and worker nodes. You also use **inventory.yml** to destroy the cluster.

The following **inventory.yml** example shows you the parameters and their default values. The quantities and numbers in these default values meet the requirements for running a production OpenShift Container Platform cluster in a RHV environment.

Example inventory.yml file

```
---
all:
  vars:

    ovirt_cluster: "Default"
    ocp:
      assets_dir: "{{ lookup('env', 'ASSETS_DIR') }}"
      ovirt_config_path: "{{ lookup('env', 'HOME') }}/.ovirt/ovirt-config.yaml"

    # ---
    # {op-system} section
    # ---
    rhcos:
      image_url: "https://mirror.openshift.com/pub/openshift-v4/dependencies/rhcos/4.11/latest/rhcos-
openstack.x86_64.qcow2.gz"
      local_cmp_image_path: "/tmp/rhcos.qcow2.gz"
      local_image_path: "/tmp/rhcos.qcow2"

    # ---
    # Profiles section
    # ---
    control_plane:
      cluster: "{{ ovirt_cluster }}"
      memory: 16GiB
```

```
    sockets: 4
    cores: 1
    template: rhcos_tpl
    operating_system: "rhcos_x64"
    type: high_performance
    graphical_console:
      headless_mode: false
      protocol:
      - spice
      - vnc
    disks:
    - size: 120GiB
      name: os
      interface: virtio_scsi
      storage_domain: depot_nvme
    nics:
    - name: nic1
      network: lab
      profile: lab

  compute:
    cluster: "{{ ovirt_cluster }}"
    memory: 16GiB
    sockets: 4
    cores: 1
    template: worker_rhcos_tpl
    operating_system: "rhcos_x64"
    type: high_performance
    graphical_console:
      headless_mode: false
      protocol:
      - spice
      - vnc
    disks:
    - size: 120GiB
      name: os
      interface: virtio_scsi
      storage_domain: depot_nvme
    nics:
    - name: nic1
      network: lab
      profile: lab

  # ---
  # Virtual machines section
  # ---
  vms:
  - name: "{{ metadata.infraID }}-bootstrap"
    ocp_type: bootstrap
    profile: "{{ control_plane }}"
    type: server
  - name: "{{ metadata.infraID }}-master0"
    ocp_type: master
    profile: "{{ control_plane }}"
  - name: "{{ metadata.infraID }}-master1"
    ocp_type: master
```

```
    profile: "{{ control_plane }}"
  - name: "{{ metadata.infraID }}-master2"
    ocp_type: master
    profile: "{{ control_plane }}"
  - name: "{{ metadata.infraID }}-worker0"
    ocp_type: worker
    profile: "{{ compute }}"
  - name: "{{ metadata.infraID }}-worker1"
    ocp_type: worker
    profile: "{{ compute }}"
  - name: "{{ metadata.infraID }}-worker2"
    ocp_type: worker
    profile: "{{ compute }}"
```

IMPORTANT

Enter values for parameters whose descriptions begin with "Enter." Otherwise, you can use the default value or replace it with a new value.

General section

- **ovirt_cluster**: Enter the name of an existing RHV cluster in which to install the OpenShift Container Platform cluster.
- **ocp.assets_dir**: The path of a directory the **openshift-install** installation program creates to store the files that it generates.
- **ocp.ovirt_config_path**: The path of the **ovirt-config.yaml** file the installation program generates, for example, **./wrk/install-config.yaml**. This file contains the credentials required to interact with the REST API of the Manager.

Red Hat Enterprise Linux CoreOS (RHCOS) section

- **image_url**: Enter the URL of the RHCOS image you specified for download.
- **local_cmp_image_path**: The path of a local download directory for the compressed RHCOS image.
- **local_image_path**: The path of a local directory for the extracted RHCOS image.

Profiles section

This section consists of two profiles:

- **control_plane**: The profile of the bootstrap and control plane nodes.
- **compute**: The profile of workers nodes in the compute plane.

These profiles have the following parameters. The default values of the parameters meet the minimum requirements for running a production cluster. You can increase or customize these values to meet your workload requirements.

- **cluster**: The value gets the cluster name from **ovirt_cluster** in the General Section.
- **memory**: The amount of memory, in GB, for the virtual machine.

- **sockets**: The number of sockets for the virtual machine.
- **cores**: The number of cores for the virtual machine.
- **template**: The name of the virtual machine template. If plan to install multiple clusters, and these clusters use templates that contain different specifications, prepend the template name with the ID of the cluster.
- **operating_system**: The type of guest operating system in the virtual machine. With oVirt/RHV version 4.4, this value must be **rhcos_x64** so the value of **Ignition script** can be passed to the VM.
- **type**: Enter **server** as the type of the virtual machine.

IMPORTANT

You must change the value of the **type** parameter from **high_performance** to **server**.

- **disks**: The disk specifications. The **control_plane** and **compute** nodes can have different storage domains.
- **size**: The minimum disk size.
- **name**: Enter the name of a disk connected to the target cluster in RHV.
- **interface**: Enter the interface type of the disk you specified.
- **storage_domain**: Enter the storage domain of the disk you specified.
- **nics**: Enter the **name** and **network** the virtual machines use. You can also specify the virtual network interface profile. By default, NICs obtain their MAC addresses from the oVirt/RHV MAC pool.

Virtual machines section

This final section, **vms**, defines the virtual machines you plan to create and deploy in the cluster. By default, it provides the minimum number of control plane and worker nodes for a production environment.

vms contains three required elements:

- **name**: The name of the virtual machine. In this case, **metadata.infraID** prepends the virtual machine name with the infrastructure ID from the **metadata.yml** file.
- **ocp_type**: The role of the virtual machine in the OpenShift Container Platform cluster. Possible values are **bootstrap**, **master**, **worker**.
- **profile**: The name of the profile from which each virtual machine inherits specifications. Possible values in this example are **control_plane** or **compute**.
  You can override the value a virtual machine inherits from its profile. To do this, you add the name of the profile attribute to the virtual machine in **inventory.yml** and assign it an overriding value. To see an example of this, examine the **name: "{{ metadata.infraID }}-bootstrap"** virtual machine in the preceding **inventory.yml** example: It has a **type** attribute whose value, **server**, overrides the value of the **type** attribute this virtual machine would otherwise inherit from the **control_plane** profile.

Metadata variables

For virtual machines, **metadata.infraID** prepends the name of the virtual machine with the infrastructure ID from the **metadata.json** file you create when you build the Ignition files.

The playbooks use the following code to read **infraID** from the specific file located in the **ocp.assets_dir**.

```
---
- name: include metadata.json vars
  include_vars:
    file: "{{ ocp.assets_dir }}/metadata.json"
    name: metadata

  ...
```

20.5.13. Specifying the RHCOS image settings

Update the Red Hat Enterprise Linux CoreOS (RHCOS) image settings of the **inventory.yml** file. Later, when you run this file one of the playbooks, it downloads a compressed Red Hat Enterprise Linux CoreOS (RHCOS) image from the **image_url** URL to the **local_cmp_image_path** directory. The playbook then uncompresses the image to the **local_image_path** directory and uses it to create oVirt/RHV templates.

Procedure

1. Locate the RHCOS image download page for the version of OpenShift Container Platform you are installing, such as Index of /pub/openshift-v4/dependencies/rhcos/latest/latest.
2. From that download page, copy the URL of an OpenStack **qcow2** image, such as **https://mirror.openshift.com/pub/openshift-v4/dependencies/rhcos/4.11/latest/rhcos-openstack.x86_64.qcow2.gz**.
3. Edit the **inventory.yml** playbook you downloaded earlier. In it, paste the URL as the value for **image_url**. For example:

```
rhcos:
  "https://mirror.openshift.com/pub/openshift-v4/dependencies/rhcos/4.11/latest/rhcos-openstack.x86_64.qcow2.gz"
```

20.5.14. Creating the install config file

You create an installation configuration file by running the installation program, **openshift-install**, and responding to its prompts with information you specified or gathered earlier.

When you finish responding to the prompts, the installation program creates an initial version of the **install-config.yaml** file in the assets directory you specified earlier, for example, **./wrk/install-config.yaml**

The installation program also creates a file, **$HOME/.ovirt/ovirt-config.yaml**, that contains all the connection parameters that are required to reach the Manager and use its REST API.

NOTE: The installation process does not use values you supply for some parameters, such as **Internal API virtual IP** and **Ingress virtual IP**, because you have already configured them in your infrastructure DNS.

It also uses the values you supply for parameters in **inventory.yml**, like the ones for **oVirt cluster**, **oVirt storage**, and **oVirt network**. And uses a script to remove or replace these same values from **install-config.yaml** with the previously mentioned **virtual IPs**.

Procedure

1. Run the installation program:

```
$ openshift-install create install-config --dir $ASSETS_DIR
```

2. Respond to the installation program's prompts with information about your system.

Example output

```
? SSH Public Key /home/user/.ssh/id_dsa.pub
? Platform <ovirt>
? Engine FQDN[:PORT] [? for help] <engine.fqdn>
? Enter ovirt-engine username <ocpadmin@internal>
? Enter password <******>
? oVirt cluster <cluster>
? oVirt storage <storage>
? oVirt network <net>
? Internal API virtual IP <172.16.0.252>
? Ingress virtual IP <172.16.0.251>
? Base Domain <example.org>
? Cluster Name <ocp4>
? Pull Secret [? for help] <********>
```


```
? SSH Public Key /home/user/.ssh/id_dsa.pub
? Platform <ovirt>
? Engine FQDN[:PORT] [? for help] <engine.fqdn>
? Enter ovirt-engine username <ocpadmin@internal>
? Enter password <******>
? oVirt cluster <cluster>
? oVirt storage <storage>
? oVirt network <net>
? Internal API virtual IP <172.16.0.252>
? Ingress virtual IP <172.16.0.251>
? Base Domain <example.org>
? Cluster Name <ocp4>
? Pull Secret [? for help] <********>
```


For **Internal API virtual IP** and **Ingress virtual IP**, supply the IP addresses you specified when you configured the DNS service.

Together, the values you enter for the **oVirt cluster** and **Base Domain** prompts form the FQDN portion of URLs for the REST API and any applications you create, such as **https://api.ocp4.example.org:6443/** and **https://console-openshift-console.apps.ocp4.example.org**.

You can get the pull secret from the Red Hat OpenShift Cluster Manager .

20.5.15. Sample install-config.yaml file for RHV

You can customize the **install-config.yaml** file to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.

```
apiVersion: v1
baseDomain: example.com (1)
compute: (2)
- hyperthreading: Enabled (3)
  name: worker
  replicas: 0 (4)
controlPlane: (5)
  hyperthreading: Enabled (6)
  name: master
  replicas: 3 (7)
metadata:
  name: test (8)
networking:
  clusterNetwork:
  - cidr: 10.128.0.0/14 (9)
    hostPrefix: 23 (10)
  networkType: OpenShiftSDN
  serviceNetwork: (11)
  - 172.30.0.0/16
platform:
  none: {} (12)
fips: false (13)
pullSecret: '{"auths": ...}' (14)
sshKey: 'ssh-ed25519 AAAA...' (15)
```

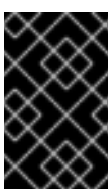
(1) The base domain of the cluster. All DNS records must be sub-domains of this base and include the cluster name.

(2) (5) The **controlPlane** section is a single mapping, but the **compute** section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, **-**, and the first line of the **controlPlane** section must not. Only one control plane pool is used.

(3) (6) Specifies whether to enable or disable simultaneous multithreading (SMT), or hyperthreading. By default, SMT is enabled to increase the performance of the cores in your machines. You can disable it by setting the parameter value to **Disabled**. If you disable SMT, you must disable it in all cluster machines; this includes both control plane and compute machines.

NOTE

Simultaneous multithreading (SMT) is enabled by default. If SMT is not enabled in your BIOS settings, the **hyperthreading** parameter has no effect.

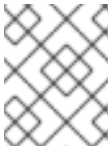


IMPORTANT

If you disable **hyperthreading**, whether in the BIOS or in the **install-config.yaml** file, ensure that your capacity planning accounts for the dramatically decreased machine performance.

(4)

You must set this value to **0** when you install OpenShift Container Platform on user-provisioned infrastructure. In installer-provisioned installations, the parameter controls the number of compute



NOTE

If you are installing a three-node cluster, do not deploy any compute machines when you install the Red Hat Enterprise Linux CoreOS (RHCOS) machines.

7 The number of control plane machines that you add to the cluster. Because the cluster uses these values as the number of etcd endpoints in the cluster, the value must match the number of control plane machines that you deploy.

8 The cluster name that you specified in your DNS records.

9 A block of IP addresses from which pod IP addresses are allocated. This block must not overlap with existing physical networks. These IP addresses are used for the pod network. If you need to access the pods from an external network, you must configure load balancers and routers to manage the traffic.

NOTE

Class E CIDR range is reserved for a future use. To use the Class E CIDR range, you must ensure your networking environment accepts the IP addresses within the Class E CIDR range.

10 The subnet prefix length to assign to each individual node. For example, if **hostPrefix** is set to **23**, then each node is assigned a **/23** subnet out of the given **cidr**, which allows for 510 (2^(32 - 23) - 2) pod IP addresses. If you are required to provide access to nodes from an external network, configure load balancers and routers to manage the traffic.

11 The IP address pool to use for service IP addresses. You can enter only one IP address pool. This block must not overlap with existing physical networks. If you need to access the services from an external network, configure load balancers and routers to manage the traffic.

12 You must set the platform to **none**. You cannot provide additional platform configuration variables for RHV infrastructure.

IMPORTANT

Clusters that are installed with the platform type **none** are unable to use some features, such as managing compute machines with the Machine API. This limitation applies even if the compute machines that are attached to the cluster are installed on a platform that would normally support the feature. This parameter cannot be changed after installation.

13 Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.

IMPORTANT

To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.

14 The pull secret from the Red Hat OpenShift Cluster Manager . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

15 The SSH public key for the **core** user in Red Hat Enterprise Linux CoreOS (RHCOS).

NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

20.5.15.1. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.

NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
```

```
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
```

1. A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
2. A proxy URL to use for creating HTTPS connections outside the cluster.
3. A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use * to bypass the proxy for all destinations.
4. If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace that contains one or more additional CA certificates that are required for proxying HTTPS connections. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges these contents with the Red Hat Enterprise Linux CoreOS (RHCOS) trust bundle, and this config map is referenced in the **trustedCA** field of the **Proxy** object. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.

NOTE

The installation program does not support the proxy **readinessEndpoints** field.

NOTE

If the installer times out, restart and then complete the deployment by using the **wait-for** command of the installer. For example:

```
$ ./openshift-install wait-for install-complete --log-level debug
```

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.

NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

20.5.16. Customizing install-config.yaml

Here, you use three Python scripts to override some of the installation program's default behaviors:

- By default, the installation program uses the machine API to create nodes. To override this default behavior, you set the number of compute nodes to zero replicas. Later, you use Ansible playbooks to create the compute nodes.
- By default, the installation program sets the IP range of the machine network for nodes. To override this default behavior, you set the IP range to match your infrastructure.
- By default, the installation program sets the platform to **ovirt**. However, installing a cluster on user-provisioned infrastructure is more similar to installing a cluster on bare metal. Therefore, you delete the ovirt platform section from **install-config.yaml** and change the platform to **none**. Instead, you use **inventory.yml** to specify all of the required settings.

NOTE

These snippets work with Python 3 and Python 2.

Procedure

1. Set the number of compute nodes to zero replicas:

```
$ python3 -c 'import os, yaml
path = "%s/install-config.yaml" % os.environ["ASSETS_DIR"]
conf = yaml.safe_load(open(path))
conf["compute"][0]["replicas"] = 0
open(path, "w").write(yaml.dump(conf, default_flow_style=False))'
```

2. Set the IP range of the machine network. For example, to set the range to **172.16.0.0/16**, enter:

```
$ python3 -c 'import os, yaml
path = "%s/install-config.yaml" % os.environ["ASSETS_DIR"]
conf = yaml.safe_load(open(path))
conf["networking"]["machineNetwork"][0]["cidr"] = "172.16.0.0/16"
open(path, "w").write(yaml.dump(conf, default_flow_style=False))'
```

3. Remove the **ovirt** section and change the platform to **none**:

```
$ python3 -c 'import os, yaml
path = "%s/install-config.yaml" % os.environ["ASSETS_DIR"]
conf = yaml.safe_load(open(path))
platform = conf["platform"]
del platform["ovirt"]
platform["none"] = {}
open(path, "w").write(yaml.dump(conf, default_flow_style=False))'
```

WARNING

Red Hat Virtualization does not currently support installation with user-provisioned infrastructure on the oVirt platform. Therefore, you must set the platform to **none**, allowing OpenShift Container Platform to identify each node as a bare-metal node and the cluster as a bare-metal cluster. This is the same as installing a cluster on any platform, and has the following limitations:

1. There will be no cluster provider so you must manually add each machine and there will be no node scaling capabilities.
2. The oVirt CSI driver will not be installed and there will be no CSI capabilities.

20.5.17. Generate manifest files

Use the installation program to generate a set of manifest files in the assets directory.

The command to generate the manifest files displays a warning message before it consumes the **install-config.yaml** file.

If you plan to reuse the **install-config.yaml** file, create a backup copy of it before you back it up before you generate the manifest files.

Procedure

1. Optional: Create a backup copy of the **install-config.yaml** file:

```
$ cp install-config.yaml install-config.yaml.backup
```

2. Generate a set of manifests in your assets directory:

```
$ openshift-install create manifests --dir $ASSETS_DIR
```

This command displays the following messages.

Example output

```
INFO Consuming Install Config from target directory
WARNING Making control-plane schedulable by setting MastersSchedulable to true for
Scheduler cluster settings
```

The command generates the following manifest files:

Example output

```
$ tree
.
└── wrk
```

```
├── manifests
│   ├── 04-openshift-machine-config-operator.yaml
│   ├── cluster-config.yaml
│   ├── cluster-dns-02-config.yml
│   ├── cluster-infrastructure-02-config.yml
│   ├── cluster-ingress-02-config.yml
│   ├── cluster-network-01-crd.yml
│   ├── cluster-network-02-config.yml
│   ├── cluster-proxy-01-config.yaml
│   ├── cluster-scheduler-02-config.yml
│   ├── cvo-overrides.yaml
│   ├── etcd-ca-bundle-configmap.yaml
│   ├── etcd-client-secret.yaml
│   ├── etcd-host-service-endpoints.yaml
│   ├── etcd-host-service.yaml
│   ├── etcd-metric-client-secret.yaml
│   ├── etcd-metric-serving-ca-configmap.yaml
│   ├── etcd-metric-signer-secret.yaml
│   ├── etcd-namespace.yaml
│   ├── etcd-service.yaml
│   ├── etcd-serving-ca-configmap.yaml
│   ├── etcd-signer-secret.yaml
│   ├── kube-cloud-config.yaml
│   ├── kube-system-configmap-root-ca.yaml
│   ├── machine-config-server-tls-secret.yaml
│   └── openshift-config-secret-pull-secret.yaml
└── openshift
    ├── 99_kubeadmin-password-secret.yaml
    ├── 99_openshift-cluster-api_master-user-data-secret.yaml
    ├── 99_openshift-cluster-api_worker-user-data-secret.yaml
    ├── 99_openshift-machineconfig_99-master-ssh.yaml
    ├── 99_openshift-machineconfig_99-worker-ssh.yaml
    └── openshift-install-manifests.yaml
```

Next steps

- Make control plane nodes non-schedulable.

20.5.18. Making control-plane nodes non-schedulable

Because you are manually creating and deploying the control plane machines, you must configure a manifest file to make the control plane nodes non-schedulable.

Procedure

1. To make the control plane nodes non-schedulable, enter:

```
$ python3 -c 'import os, yaml
path = "%s/manifests/cluster-scheduler-02-config.yml" % os.environ["ASSETS_DIR"]
data = yaml.safe_load(open(path))
data["spec"]["mastersSchedulable"] = False
open(path, "w").write(yaml.dump(data, default_flow_style=False))'
```

20.5.19. Building the Ignition files

To build the Ignition files from the manifest files you just generated and modified, you run the installation program. This action creates a Red Hat Enterprise Linux CoreOS (RHCOS) machine, **initramfs**, which fetches the Ignition files and performs the configurations needed to create a node.

In addition to the Ignition files, the installation program generates the following:

- An **auth** directory that contains the admin credentials for connecting to the cluster with the **oc** and **kubectl** utilities.
- A **metadata.json** file that contains information such as the OpenShift Container Platform cluster name, cluster ID, and infrastructure ID for the current installation.

The Ansible playbooks for this installation process use the value of **infraID** as a prefix for the virtual machines they create. This prevents naming conflicts when there are multiple installations in the same oVirt/RHV cluster.

NOTE

Certificates in Ignition configuration files expire after 24 hours. Complete the cluster installation and keep the cluster running in a non-degraded state for 24 hours so that the first certificate rotation can finish.

Procedure

1. To build the Ignition files, enter:

```
$ openshift-install create ignition-configs --dir $ASSETS_DIR
```

Example output

```
$ tree
.
└── wrk
    ├── auth
    │   ├── kubeadmin-password
    │   └── kubeconfig
    ├── bootstrap.ign
    ├── master.ign
    ├── metadata.json
    └── worker.ign
```

20.5.20. Creating templates and virtual machines

After confirming the variables in the **inventory.yml**, you run the first Ansible provisioning playbook, **create-templates-and-vms.yml**.

This playbook uses the connection parameters for the RHV Manager from **$HOME/.ovirt/ovirt-config.yaml** and reads **metadata.json** in the assets directory.

If a local Red Hat Enterprise Linux CoreOS (RHCOS) image is not already present, the playbook downloads one from the URL you specified for **image_url** in **inventory.yml**. It extracts the image and uploads it to RHV to create templates.

The playbook creates a template based on the **control_plane** and **compute** profiles in the **inventory.yml** file. If these profiles have different names, it creates two templates.

When the playbook finishes, the virtual machines it creates are stopped. You can get information from them to help configure other infrastructure elements. For example, you can get the virtual machines' MAC addresses to configure DHCP to assign permanent IP addresses to the virtual machines.

Procedure

1. In **inventory.yml**, under the **control_plane** and **compute** variables, change both instances of **type: high_performance** to **type: server**.
2. Optional: If you plan to perform multiple installations to the same cluster, create different templates for each OpenShift Container Platform installation. In the **inventory.yml** file, prepend the value of **template** with **infraID**. For example:

```
control_plane:
  cluster: "{{ ovirt_cluster }}"
  memory: 16GiB
  sockets: 4
  cores: 1
  template: "{{ metadata.infraID }}-rhcos_tpl"
  operating_system: "rhcos_x64"
  ...
```

3. Create the templates and virtual machines:

```
$ ansible-playbook -i inventory.yml create-templates-and-vms.yml
```

20.5.21. Creating the bootstrap machine

You create a bootstrap machine by running the **bootstrap.yml** playbook. This playbook starts the bootstrap virtual machine, and passes it the **bootstrap.ign** Ignition file from the assets directory. The bootstrap node configures itself so it can serve Ignition files to the control plane nodes.

To monitor the bootstrap process, you use the console in the RHV Administration Portal or connect to the virtual machine by using SSH.

Procedure

1. Create the bootstrap machine:

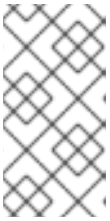
```
$ ansible-playbook -i inventory.yml bootstrap.yml
```

2. Connect to the bootstrap machine using a console in the Administration Portal or SSH. Replace **<bootstrap_ip>** with the bootstrap node IP address. To use SSH, enter:

```
$ ssh core@<boostrap.ip>
```

3. Collect **bootkube.service** journald unit logs for the release image service from the bootstrap node:

```
[core@ocp4-lk6b4-bootstrap ~]$ journalctl -b -f -u release-image.service -u bootkube.service
```



NOTE

The **bootkube.service** log on the bootstrap node outputs etcd **connection refused** errors, indicating that the bootstrap server is unable to connect to etcd on control plane nodes. After etcd has started on each control plane node and the nodes have joined the cluster, the errors should stop.

20.5.22. Creating the control plane nodes

You create the control plane nodes by running the **masters.yml** playbook. This playbook passes the **master.ign** Ignition file to each of the virtual machines. The Ignition file contains a directive for the control plane node to get the Ignition from a URL such as **https://api-int.ocp4.example.org:22623/config/master**. The port number in this URL is managed by the load balancer, and is accessible only inside the cluster.

Procedure

1. Create the control plane nodes:

```
$ ansible-playbook -i inventory.yml masters.yml
```

2. While the playbook creates your control plane, monitor the bootstrapping process:

```
$ openshift-install wait-for bootstrap-complete --dir $ASSETS_DIR
```

Example output

```
INFO API v1.24.0 up
INFO Waiting up to 40m0s for bootstrapping to complete...
```

3. When all the pods on the control plane nodes and etcd are up and running, the installation program displays the following output.

Example output

```
INFO It is now safe to remove the bootstrap resources
```

20.5.23. Verifying cluster status

You can verify your OpenShift Container Platform cluster's status during or after installation.

Procedure

1. In the cluster environment, export the administrator's kubeconfig file:

```
$ export KUBECONFIG=$ASSETS_DIR/auth/kubeconfig
```

The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server.

2. View the control plane and compute machines created after a deployment:

```
$ oc get nodes
```

3. View your cluster's version:

```
$ oc get clusterversion
```

4. View your Operators' status:

```
$ oc get clusteroperator
```

5. View all running pods in the cluster:

```
$ oc get pods -A
```

20.5.24. Removing the bootstrap machine

After the **wait-for** command shows that the bootstrap process is complete, you must remove the bootstrap virtual machine to free up compute, memory, and storage resources. Also, remove settings for the bootstrap machine from the load balancer directives.

Procedure

1. To remove the bootstrap machine from the cluster, enter:

```
$ ansible-playbook -i inventory.yml retire-bootstrap.yml
```

2. Remove settings for the bootstrap machine from the load balancer directives.

20.5.25. Creating the worker nodes and completing the installation

Creating worker nodes is similar to creating control plane nodes. However, worker nodes workers do not automatically join the cluster. To add them to the cluster, you review and approve the workers' pending CSRs (Certificate Signing Requests).

After approving the first requests, you continue approving CSR until all of the worker nodes are approved. When you complete this process, the worker nodes become **Ready** and can have pods scheduled to run on them.

Finally, monitor the command line to see when the installation process completes.

Procedure

1. Create the worker nodes:

```
$ ansible-playbook -i inventory.yml workers.yml
```

2. To list all of the CSRs, enter:

```
$ oc get csr -A
```

   Eventually, this command displays one CSR per node. For example:

   Example output

```
NAME        AGE    SIGNERNAME                                    REQUESTOR
CONDITION
csr-2lnxd   63m    kubernetes.io/kubelet-serving                 system:node:ocp4-lk6b4-
master0.ocp4.example.org                 Approved,Issued
csr-hff4q   64m    kubernetes.io/kube-apiserver-client-kubelet
system:serviceaccount:openshift-machine-config-operator:node-bootstrapper
Approved,Issued
csr-hsn96   60m    kubernetes.io/kubelet-serving                 system:node:ocp4-lk6b4-
master2.ocp4.example.org                 Approved,Issued
csr-m724n   6m2s   kubernetes.io/kube-apiserver-client-kubelet
system:serviceaccount:openshift-machine-config-operator:node-bootstrapper   Pending
csr-p4dz2   60m    kubernetes.io/kube-apiserver-client-kubelet
system:serviceaccount:openshift-machine-config-operator:node-bootstrapper
Approved,Issued
csr-t9vfj   60m    kubernetes.io/kubelet-serving                 system:node:ocp4-lk6b4-
master1.ocp4.example.org                 Approved,Issued
csr-tggtr   61m    kubernetes.io/kube-apiserver-client-kubelet
system:serviceaccount:openshift-machine-config-operator:node-bootstrapper
Approved,Issued
csr-wcbrf   7m6s   kubernetes.io/kube-apiserver-client-kubelet
system:serviceaccount:openshift-machine-config-operator:node-bootstrapper   Pending
```

3. To filter the list and see only pending CSRs, enter:

```
$ watch "oc get csr -A | grep pending -i"
```

This command refreshes the output every two seconds and displays only pending CSRs. For example:

Example output

```
Every 2.0s: oc get csr -A | grep pending -i

csr-m724n   10m   kubernetes.io/kube-apiserver-client-kubelet
system:serviceaccount:openshift-machine-config-operator:node-bootstrapper   Pending
csr-wcbrf   11m   kubernetes.io/kube-apiserver-client-kubelet
system:serviceaccount:openshift-machine-config-operator:node-bootstrapper   Pending
```

4. Inspect each pending request. For example:

Example output

```
$ oc describe csr csr-m724n
```

Example output

```
Name:               csr-m724n
Labels:             <none>
Annotations:        <none>
CreationTimestamp:  Sun, 19 Jul 2020 15:59:37 +0200
Requesting User:    system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper
Signer:             kubernetes.io/kube-apiserver-client-kubelet
Status:             Pending
```

```
Subject:
        Common Name:    system:node:ocp4-lk6b4-worker1.ocp4.example.org
        Serial Number:
        Organization:   system:nodes
Events:  <none>
```

5. If the CSR information is correct, approve the request:

```
$ oc adm certificate approve csr-m724n
```

6. Wait for the installation process to finish:

```
$ openshift-install wait-for install-complete --dir $ASSETS_DIR --log-level debug
```

When the installation completes, the command line displays the URL of the OpenShift Container Platform web console and the administrator user name and password.

20.5.26. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.11, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to OpenShift Cluster Manager Hybrid Cloud Console.

After you confirm that your OpenShift Cluster Manager Hybrid Cloud Console inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, use subscription watch to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

Additional resources

- See About remote health monitoring for more information about the Telemetry service

20.5.27. Disabling the default OperatorHub sources

Operator catalogs that source content provided by Red Hat and community projects are configured for OperatorHub by default during an OpenShift Container Platform installation. In a restricted network environment, you must disable the default catalogs as a cluster administrator.

Procedure

- Disable the sources for the default catalogs by adding **disableAllDefaultSources: true** to the **OperatorHub** object:

```
$ oc patch OperatorHub cluster --type json \
    -p '[{"op": "add", "path": "/spec/disableAllDefaultSources", "value": true}]'
```

TIP

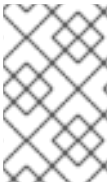
Alternatively, you can use the web console to manage catalog sources. From the **Administration → Cluster Settings → Configuration → OperatorHub** page, click the **Sources** tab, where you can create, update, delete, disable, and enable individual sources.

20.6. UNINSTALLING A CLUSTER ON RHV

You can remove an OpenShift Container Platform cluster from Red Hat Virtualization (RHV).

20.6.1. Removing a cluster that uses installer-provisioned infrastructure

You can remove a cluster that uses installer-provisioned infrastructure from your cloud.



NOTE

After uninstallation, check your cloud provider for any resources not removed properly, especially with User Provisioned Infrastructure (UPI) clusters. There might be resources that the installer did not create or that the installer is unable to access.

Prerequisites

- You have a copy of the installation program that you used to deploy the cluster.
- You have the files that the installation program generated when you created your cluster.

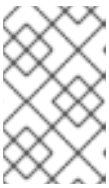
Procedure

1. On the computer that you used to install the cluster, go to the directory that contains the installation program, and run the following command:

```
$ ./openshift-install destroy cluster \
--dir <installation_directory> --log-level info 1 2
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2 To view different details, specify **warn**, **debug**, or **error** instead of **info**.



NOTE

You must specify the directory that contains the cluster definition files for your cluster. The installation program requires the **metadata.json** file in this directory to delete the cluster.

2. Optional: Delete the **<installation_directory>** directory and the OpenShift Container Platform installation program.

20.6.2. Removing a cluster that uses user-provisioned infrastructure

When you are finished using the cluster, you can remove a cluster that uses user-provisioned infrastructure from your cloud.

Prerequisites

- Have the original playbook files, assets directory and files, and **$ASSETS_DIR** environment variable that you used to you install the cluster. Typically, you can achieve this by using the same computer you used when you installed the cluster.

Procedure

1. To remove the cluster, enter:

```
$ ansible-playbook -i inventory.yml \
    retire-bootstrap.yml \
    retire-masters.yml    \
    retire-workers.yml
```

2. Remove any configurations you added to DNS, load balancers, and any other infrastructure for this cluster.

CHAPTER 21. INSTALLING ON VSPHERE

21.1. PREPARING TO INSTALL ON VSPHERE

21.1.1. Prerequisites

- You reviewed details about the OpenShift Container Platform installation and update processes.
- You read the documentation on selecting a cluster installation method and preparing it for users.
- If you use a firewall and plan to use Telemetry, you configured the firewall to allow the sites required by your cluster.
- You reviewed your VMware platform licenses. Red Hat does not place any restrictions on your VMware licenses, but some VMware infrastructure components require licensing.

21.1.2. Choosing a method to install OpenShift Container Platform on vSphere

You can install OpenShift Container Platform on vSphere by using installer-provisioned or user-provisioned infrastructure. The default installation type uses installer-provisioned infrastructure, where the installation program provisions the underlying infrastructure for the cluster. You can also install OpenShift Container Platform on infrastructure that you provide. If you do not use infrastructure that the installation program provisions, you must manage and maintain the cluster resources yourself.

See the Installation process for more information about installer-provisioned and user-provisioned installation processes.

IMPORTANT

The steps for performing a user-provisioned infrastructure installation are provided as an example only. Installing a cluster with infrastructure you provide requires knowledge of the vSphere platform and the installation process of OpenShift Container Platform. Use the user-provisioned infrastructure installation instructions as a guide; you are free to create the required resources through other methods.

21.1.2.1. Installer-provisioned infrastructure installation of OpenShift Container Platform on vSphere

Installer-provisioned infrastructure allows the installation program to preconfigure and automate the provisioning of resources required by OpenShift Container Platform.

- **Installing a cluster on vSphere**: You can install OpenShift Container Platform on vSphere by using installer-provisioned infrastructure installation with no customization.
- **Installing a cluster on vSphere with customizations**: You can install OpenShift Container Platform on vSphere by using installer-provisioned infrastructure installation with the default customization options.
- **Installing a cluster on vSphere with network customizations**: You can install OpenShift Container Platform on installer-provisioned vSphere infrastructure, with network customizations. You can customize your OpenShift Container Platform network configuration

during installation, so that your cluster can coexist with your existing IP address allocations and adhere to your network requirements.

- **Installing a cluster on vSphere in a restricted network**: You can install a cluster on VMware vSphere infrastructure in a restricted network by creating an internal mirror of the installation release content. You can use this method to deploy OpenShift Container Platform on an internal network that is not visible to the internet.

21.1.2.2. User-provisioned infrastructure installation of OpenShift Container Platform on vSphere

User-provisioned infrastructure requires the user to provision all resources required by OpenShift Container Platform.

- **Installing a cluster on vSphere with user-provisioned infrastructure**: You can install OpenShift Container Platform on VMware vSphere infrastructure that you provision.
- **Installing a cluster on vSphere with network customizations with user-provisioned infrastructure**: You can install OpenShift Container Platform on VMware vSphere infrastructure that you provision with customized network configuration options.
- **Installing a cluster on vSphere in a restricted network with user-provisioned infrastructure**: OpenShift Container Platform can be installed on VMware vSphere infrastructure that you provision in a restricted network.

21.1.3. VMware vSphere infrastructure requirements

You must install the OpenShift Container Platform cluster on a VMware vSphere version 7 instance that meets the requirements for the components that you use.

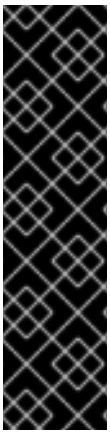
NOTE

OpenShift Container Platform version 4.11 does not support VMware vSphere version 8.0.

You can host the VMware vSphere infrastructure on-premise or on a VMware Cloud Verified provider that meets the requirements outlined in the following table:

Table 21.1. Version requirements for vSphere virtual environments

Virtual environment product	Required version
VM hardware version	15 or later
vSphere ESXi hosts	7
vCenter host	7



IMPORTANT

Installing a cluster on VMware vSphere version 7.0 Update 1 or earlier is now deprecated. These versions are still fully supported, but version 4.11 of OpenShift Container Platform requires vSphere virtual hardware version 15 or later. Hardware version 15 is now the default for vSphere virtual machines in OpenShift Container Platform. To update the hardware version for your vSphere nodes, see the "Updating hardware on nodes running in vSphere" article.

If your vSphere nodes are below hardware version 15 or your VMware vSphere version is earlier than 6.7.3, upgrading from OpenShift Container Platform 4.10 to OpenShift Container Platform 4.11 is not available.

Table 21.2. Minimum supported vSphere version for VMware components

Component	Minimum supported versions	Description
Hypervisor	vSphere 7 with HW version 15	This version is the minimum version that Red Hat Enterprise Linux CoreOS (RHCOS) supports. For more information about supported hardware on the latest version of Red Hat Enterprise Linux (RHEL) that is compatible with RHCOS, see Hardware on the Red Hat Customer Portal.
Storage with in-tree drivers	vSphere 7	This plugin creates vSphere storage by using the in-tree storage drivers for vSphere included in OpenShift Container Platform.
Optional: Networking (NSX-T)	vSphere 7	vSphere 7 is required for OpenShift Container Platform. For more information about the compatibility of NSX and OpenShift Container Platform, see the Release Notes section of VMware's NSX container plugin documentation.

IMPORTANT

You must ensure that the time on your ESXi hosts is synchronized before you install OpenShift Container Platform. See Edit Time Configuration for a Host in the VMware documentation.

21.1.4. VMware vSphere CSI Driver Operator requirements

To install the vSphere CSI Driver Operator, the following requirements must be met:

- VMware vSphere version 7.0 Update 1 or later
- Virtual machines of hardware version 15 or later
- No third-party vSphere CSI driver already installed in the cluster

IMPORTANT

If a third-party vSphere CSI driver is present in the cluster, OpenShift Container Platform does not overwrite it. If you continue with the third-party vSphere CSI driver when upgrading to the next major version of OpenShift Container Platform, the **oc** CLI prompts you with the following message:

```
VSphereCSIDriverOperatorCRUpgradeable: VMwareVSphereControllerUpgradeable:
found existing unsupported csi.vsphere.vmware.com driver
```

The previous message informs you that Red Hat does not support the third-party vSphere CSI driver during an OpenShift Container Platform upgrade operation. You can choose to ignore this message and continue with the upgrade operation.

Additional resources

- To remove a third-party vSphere CSI driver, see Removing a third-party vSphere CSI Driver .

21.1.5. Uninstalling an installer-provisioned infrastructure installation of OpenShift Container Platform on vSphere

- **Uninstalling a cluster on vSphere that uses installer-provisioned infrastructure** You can remove a cluster that you deployed on VMware vSphere infrastructure that used installer-provisioned infrastructure.

21.2. INSTALLING A CLUSTER ON VSPHERE

In OpenShift Container Platform version 4.11, you can install a cluster on your VMware vSphere instance by using installer-provisioned infrastructure.

NOTE

OpenShift Container Platform supports deploying a cluster to a single VMware vCenter only. Deploying a cluster with machines/machine sets on multiple vCenters is not supported.

21.2.1. Prerequisites

- You reviewed details about the OpenShift Container Platform installation and update processes.
- You read the documentation on selecting a cluster installation method and preparing it for users.
- You provisioned persistent storage for your cluster. To deploy a private image registry, your storage must provide **ReadWriteMany** access modes.

- The OpenShift Container Platform installer requires access to port 443 on the vCenter and ESXi hosts. You verified that port 443 is accessible.
- If you use a firewall, you confirmed with the administrator that port 443 is accessible. Control plane nodes must be able to reach vCenter and ESXi hosts on port 443 for the installation to succeed.
- If you use a firewall, you configured it to allow the sites that your cluster requires access to.

NOTE

Be sure to also review this site list if you are configuring a proxy.

21.2.2. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.11, you require access to the internet to install your cluster.

You must have internet access to:

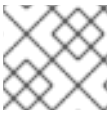
- Access OpenShift Cluster Manager Hybrid Cloud Console to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access Quay.io to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.

IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

21.2.3. VMware vSphere infrastructure requirements

You must install the OpenShift Container Platform cluster on a VMware vSphere version 7 instance that meets the requirements for the components that you use.



NOTE

OpenShift Container Platform version 4.11 does not support VMware vSphere version 8.0.

You can host the VMware vSphere infrastructure on-premise or on a VMware Cloud Verified provider that meets the requirements outlined in the following table:

Table 21.3. Version requirements for vSphere virtual environments

Virtual environment product	Required version
VM hardware version	15 or later

Virtual environment product	Required version
vSphere ESXi hosts	7
vCenter host	7

IMPORTANT

Installing a cluster on VMware vSphere version 7.0 Update 1 or earlier is now deprecated. These versions are still fully supported, but version 4.11 of OpenShift Container Platform requires vSphere virtual hardware version 15 or later. Hardware version 15 is now the default for vSphere virtual machines in OpenShift Container Platform. To update the hardware version for your vSphere nodes, see the "Updating hardware on nodes running in vSphere" article.

If your vSphere nodes are below hardware version 15 or your VMware vSphere version is earlier than 6.7.3, upgrading from OpenShift Container Platform 4.10 to OpenShift Container Platform 4.11 is not available.

Table 21.4. Minimum supported vSphere version for VMware components

Component	Minimum supported versions	Description
Hypervisor	vSphere 7 with HW version 15	This version is the minimum version that Red Hat Enterprise Linux CoreOS (RHCOS) supports. For more information about supported hardware on the latest version of Red Hat Enterprise Linux (RHEL) that is compatible with RHCOS, see Hardware on the Red Hat Customer Portal.
Storage with in-tree drivers	vSphere 7	This plugin creates vSphere storage by using the in-tree storage drivers for vSphere included in OpenShift Container Platform.
Optional: Networking (NSX-T)	vSphere 7	vSphere 7 is required for OpenShift Container Platform. For more information about the compatibility of NSX and OpenShift Container Platform, see the Release Notes section of VMware's NSX container plugin documentation.

IMPORTANT

You must ensure that the time on your ESXi hosts is synchronized before you install OpenShift Container Platform. See Edit Time Configuration for a Host in the VMware documentation.

21.2.4. Network connectivity requirements

You must configure the network connectivity between machines to allow OpenShift Container Platform cluster components to communicate.

Review the following details about the required network ports.

Table 21.5. Ports used for all-machine to all-machine communications

Protocol	Port	Description
ICMP	N/A	Network reachability tests
TCP	**1936**	Metrics
	9000-**9999**	Host level services, including the node exporter on ports **9100**-**9101** and the Cluster Version Operator on port**9099**.
	10250-**10259**	The default ports that Kubernetes reserves
	10256	openshift-sdn
UDP	**4789**	virtual extensible LAN (VXLAN)
	6081	Geneve
	9000-**9999**	Host level services, including the node exporter on ports **9100**-**9101**.
	500	IPsec IKE packets
	4500	IPsec NAT-T packets
TCP/UDP	**30000**-**32767**	Kubernetes node port
ESP	N/A	IPsec Encapsulating Security Payload (ESP)

Table 21.6. Ports used for all-machine to control plane communications

Protocol	Port	Description
TCP	**6443**	Kubernetes API

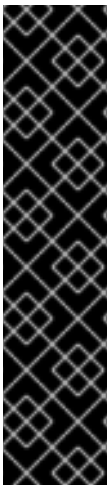
Table 21.7. Ports used for control plane machine to control plane machine communications

Protocol	Port	Description
TCP	**2379-2380**	etcd server and peer ports

21.2.5. VMware vSphere CSI Driver Operator requirements

To install the vSphere CSI Driver Operator, the following requirements must be met:

- VMware vSphere version 7.0 Update 1 or later
- Virtual machines of hardware version 15 or later
- No third-party vSphere CSI driver already installed in the cluster



IMPORTANT

If a third-party vSphere CSI driver is present in the cluster, OpenShift Container Platform does not overwrite it. If you continue with the third-party vSphere CSI driver when upgrading to the next major version of OpenShift Container Platform, the **oc** CLI prompts you with the following message:

> VSphereCSIDriverOperatorCRUpgradeable: VMwareVSphereControllerUpgradeable: found existing unsupported csi.vsphere.vmware.com driver

The previous message informs you that Red Hat does not support the third-party vSphere CSI driver during an OpenShift Container Platform upgrade operation. You can choose to ignore this message and continue with the upgrade operation.

Additional resources

- To remove a third-party vSphere CSI driver, see Removing a third-party vSphere CSI Driver .
- To update the hardware version for your vSphere nodes, see Updating hardware on nodes running in vSphere.

21.2.6. vCenter requirements

Before you install an OpenShift Container Platform cluster on your vCenter that uses infrastructure that the installer provisions, you must prepare your environment.

Required vCenter account privileges
To install an OpenShift Container Platform cluster in a vCenter, the installation program requires access to an account with privileges to read and create the required resources. Using an account that has global administrative privileges is the simplest way to access all of the necessary permissions.

If you cannot use an account with global administrative privileges, you must create roles to grant the privileges necessary for OpenShift Container Platform cluster installation. While most of the privileges are always required, some are required only if you plan for the installation program to provision a folder to contain the OpenShift Container Platform cluster on your vCenter instance, which is the default behavior. You must create or amend vSphere roles for the specified objects to grant the required privileges.

An additional role is required if the installation program is to create a vSphere virtual machine folder.

Example 21.1. Roles and privileges required for installation in vSphere API

vSphere object for role	When required	Required privileges in vSphere API
vSphere vCenter	Always	**Cns.Searchable** **InventoryService.Tagging.AttachTag** **InventoryService.Tagging.CreateCategory** **InventoryService.Tagging.CreateTag** **InventoryService.Tagging.DeleteCategory** **InventoryService.Tagging.DeleteTag** **InventoryService.Tagging.EditCategory** **InventoryService.Tagging.EditTag** **Sessions.ValidateSession** **StorageProfile.Update** **StorageProfile.View**
vSphere vCenter Cluster	If VMs will be created in the cluster root	**Host.Config.Storage** **Resource.AssignVMToPool** **VApp.AssignResourcePool** **VApp.Import** **VirtualMachine.Config.AddNewDisk**
vSphere vCenter Resource Pool	If an existing resource pool is provided	**Host.Config.Storage** **Resource.AssignVMToPool** **VApp.AssignResourcePool** **VApp.Import** **VirtualMachine.Config.AddNewDisk**
vSphere Datastore	Always	**Datastore.AllocateSpace** **Datastore.Browse** **Datastore.FileManagement** **InventoryService.Tagging.ObjectAttachable**
vSphere Port Group	Always	**Network.Assign**
Virtual Machine Folder	Always	**InventoryService.Tagging.ObjectAttachable** **Resource.AssignVMToPool** **VApp.Import** **VirtualMachine.Config.Add**

vSphere object for role	When required	Required privileges in vSphere API
		ExistingDisk **VirtualMachine.Config.AddNewDisk** **VirtualMachine.Config.AddRemoveDevice** **VirtualMachine.Config.AdvancedConfig** **VirtualMachine.Config.Annotation** **VirtualMachine.Config.CPUCount** **VirtualMachine.Config.DiskExtend** **VirtualMachine.Config.DiskLease** **VirtualMachine.Config.EditDevice** **VirtualMachine.Config.Memory** **VirtualMachine.Config.RemoveDisk** **VirtualMachine.Config.Rename** **VirtualMachine.Config.ResetGuestInfo** **VirtualMachine.Config.Resource** **VirtualMachine.Config.Settings** **VirtualMachine.Config.UpgradeVirtualHardware** **VirtualMachine.Interact.GuestControl** **VirtualMachine.Interact.PowerOff** **VirtualMachine.Interact.PowerOn** **VirtualMachine.Interact.Reset** **VirtualMachine.Inventory.Create** **VirtualMachine.Inventory.CreateFromExisting** **VirtualMachine.Inventory.Delete** **VirtualMachine.Provisioning.Clone** **VirtualMachine.Provisioning.MarkAsTemplate** **VirtualMachine.Provisioning.DeployTemplate**
vSphere vCenter Datacenter	If the installation program creates the virtual machine folder	**InventoryService.Tagging.ObjectAttachable** **Resource.AssignVMToPool** **VApp.Import**

vSphere object for role	When required	Required privileges in vSphere API
		VirtualMachine.Config.AddExistingDisk VirtualMachine.Config.AddNewDisk VirtualMachine.Config.AddRemoveDevice VirtualMachine.Config.AdvancedConfig VirtualMachine.Config.Annotation VirtualMachine.Config.CPUCount VirtualMachine.Config.DiskExtend VirtualMachine.Config.DiskLease VirtualMachine.Config.EditDevice VirtualMachine.Config.Memory VirtualMachine.Config.RemoveDisk VirtualMachine.Config.Rename VirtualMachine.Config.ResetGuestInfo VirtualMachine.Config.Resource VirtualMachine.Config.Settings VirtualMachine.Config.UpgradeVirtualHardware VirtualMachine.Interact.GuestControl VirtualMachine.Interact.PowerOff VirtualMachine.Interact.PowerOn VirtualMachine.Interact.Reset VirtualMachine.Inventory.Create VirtualMachine.Inventory.CreateFromExisting VirtualMachine.Inventory.Delete VirtualMachine.Provisioning.Clone VirtualMachine.Provisioning.DeployTemplate VirtualMachine.Provisioning.MarkAsTemplate Folder.Create Folder.Delete

Example 21.2. Roles and privileges required for installation in vCenter graphical user interface (GUI)

vSphere object for role	When required	Required privileges in vCenter GUI
vSphere vCenter	Always	**Cns.Searchable "vSphere Tagging"."Assign or Unassign vSphere Tag" "vSphere Tagging"."Create vSphere Tag Category" "vSphere Tagging"."Create vSphere Tag" vSphere Tagging"."Delete vSphere Tag Category" "vSphere Tagging"."Delete vSphere Tag" "vSphere Tagging"."Edit vSphere Tag Category" "vSphere Tagging"."Edit vSphere Tag" Sessions."Validate session" "Profile-driven storage"."Profile-driven storage update" "Profile-driven storage"."Profile-driven storage view"**
vSphere vCenter Cluster	If VMs will be created in the cluster root	**Host.Configuration."Storage partition configuration" Resource."Assign virtual machine to resource pool" VApp."Assign resource pool" VApp.Import "Virtual machine"."Change Configuration"."Add new disk"**
vSphere vCenter Resource Pool	If an existing resource pool is provided	**Host.Configuration."Storage partition configuration" Resource."Assign virtual machine to resource pool" VApp."Assign resource pool" VApp.Import "Virtual machine"."Change Configuration"."Add new disk"**

vSphere object for role	When required	Required privileges in vCenter GUI
vSphere Datastore	Always	**Datastore."Allocate space" Datastore."Browse datastore" Datastore."Low level file operations" "vSphere Tagging"."Assign or Unassign vSphere Tag on Object"**
vSphere Port Group	Always	**Network."Assign network"**
Virtual Machine Folder	Always	**"vSphere Tagging"."Assign or Unassign vSphere Tag on Object" Resource."Assign virtual machine to resource pool" VApp.Import "Virtual machine"."Change Configuration"."Add existing disk" "Virtual machine"."Change Configuration"."Add new disk" "Virtual machine"."Change Configuration"."Add or remove device" "Virtual machine"."Change Configuration"."Advanced configuration" "Virtual machine"."Change Configuration"."Set annotation" "Virtual machine"."Change Configuration"."Change CPU count" "Virtual machine"."Change Configuration"."Extend virtual disk" "Virtual machine"."Change Configuration"."Acquire disk lease" "Virtual machine"."Change Configuration"."Modify device settings" "Virtual machine"."Change Configuration"."Change Memory" "Virtual machine"."Change Configuration"."Remove**

vSphere object for role	When required	Required privileges in vCenter GUI
		disk" **"Virtual machine"."Change Configuration".Rename** **"Virtual machine"."Change Configuration"."Reset guest information"** **"Virtual machine"."Change Configuration"."Change resource"** **"Virtual machine"."Change Configuration"."Change Settings"** **"Virtual machine"."Change Configuration"."Upgrade virtual machine compatibility"** **"Virtual machine".Interaction."Guest operating system management by VIX API"** **"Virtual machine".Interaction."Power off"** **"Virtual machine".Interaction."Power on"** **"Virtual machine".Interaction.Reset** **"Virtual machine"."Edit Inventory"."Create new"** **"Virtual machine"."Edit Inventory"."Create from existing"** **"Virtual machine"."Edit Inventory"."Remove"** **"Virtual machine".Provisioning."Clone virtual machine"** **"Virtual machine".Provisioning."Mark as template"** **"Virtual machine".Provisioning."Deploy template"**
vSphere vCenter Datacenter	If the installation program creates the virtual machine folder	**"vSphere Tagging"."Assign or Unassign vSphere Tag on Object"** **Resource."Assign virtual machine to resource pool"** **VApp.Import** **"Virtual machine"."Change Configuration"."Add existing disk"** **"Virtual machine"."Change Configuration"."Add new**

vSphere object for role	When required	Required privileges in vCenter GUI
		"Virtual machine"."Change Configuration"."Add or remove device" "Virtual machine"."Change Configuration"."Advanced configuration" "Virtual machine"."Change Configuration"."Set annotation" "Virtual machine"."Change Configuration"."Change CPU count" "Virtual machine"."Change Configuration"."Extend virtual disk" "Virtual machine"."Change Configuration"."Acquire disk lease" "Virtual machine"."Change Configuration"."Modify device settings" "Virtual machine"."Change Configuration"."Change Memory" "Virtual machine"."Change Configuration"."Remove disk" "Virtual machine"."Change Configuration".Rename "Virtual machine"."Change Configuration"."Reset guest information" "Virtual machine"."Change Configuration"."Change resource" "Virtual machine"."Change Configuration"."Change Settings" "Virtual machine"."Change Configuration"."Upgrade virtual machine compatibility" "Virtual machine".Interaction."Guest operating system management by VIX API" "Virtual machine".Interaction."Power off" "Virtual machine".Interaction."Power on" "Virtual machine".Interaction.Reset "Virtual machine"."Edit

vSphere object for role	When required	Required privileges in vCenter GUI
		Inventory"."Create new" "Virtual machine"."Edit Inventory"."Create from existing" "Virtual machine"."Edit Inventory"."Remove" "Virtual machine".Provisioning."Clone virtual machine" "Virtual machine".Provisioning."Deploy template" "Virtual machine".Provisioning."Mark as template" Folder."Create folder" Folder."Delete folder"

Additionally, the user requires some **ReadOnly** permissions, and some of the roles require permission to propogate the permissions to child objects. These settings vary depending on whether or not you install the cluster into an existing folder.

Example 21.3. Required permissions and propagation settings

vSphere object	When required	Propagate to children	Permissions required
vSphere vCenter	Always	False	Listed required privileges
vSphere vCenter Datacenter	Existing folder	False	**ReadOnly** permission
	Installation program creates the folder	True	Listed required privileges
vSphere vCenter Cluster	Existing resource pool	False	**ReadOnly** permission
	VMs in cluster root	True	Listed required privileges
vSphere vCenter Datastore	Always	False	Listed required privileges
vSphere Switch	Always	False	**ReadOnly** permission
vSphere Port Group	Always	False	Listed required privileges
vSphere vCenter Virtual Machine Folder	Existing folder	True	Listed required privileges

vSphere object	When required	Propagate to children	Permissions required
vSphere vCenter Resource Pool	Existing resource pool	True	Listed required privileges

For more information about creating an account with only the required privileges, see vSphere Permissions and User Management Tasks in the vSphere documentation.

Using OpenShift Container Platform with vMotion
If you intend on using vMotion in your vSphere environment, consider the following before installing a OpenShift Container Platform cluster.

- OpenShift Container Platform generally supports compute-only vMotion, where *generally* implies that you meet all VMware best practices for vMotion.
  To help ensure the uptime of your compute and control plane nodes, ensure that you follow the VMware best practices for vMotion, and use VMware anti-affinity rules to improve the availability of OpenShift Container Platform during maintenance or hardware issues.

  For more information about vMotion and anti-affinity rules, see the VMware vSphere documentation for vMotion networking requirements and VM anti-affinity rules.

- Using Storage vMotion can cause issues and is not supported. If you are using vSphere volumes in your pods, migrating a VM across datastores, either manually or through Storage vMotion, causes invalid references within OpenShift Container Platform persistent volume (PV) objects that can result in data loss.

- OpenShift Container Platform does not support selective migration of VMDKs across datastores, using datastore clusters for VM provisioning or for dynamic or static provisioning of PVs, or using a datastore that is part of a datastore cluster for dynamic or static provisioning of PVs.

Cluster resources
When you deploy an OpenShift Container Platform cluster that uses installer-provisioned infrastructure, the installation program must be able to create several resources in your vCenter instance.

A standard OpenShift Container Platform installation creates the following vCenter resources:

- 1 Folder
- 1 Tag category
- 1 Tag
- Virtual machines:
  - 1 template
  - 1 temporary bootstrap node
  - 3 control plane nodes
  - 3 compute machines

Although these resources use 856 GB of storage, the bootstrap node is destroyed during the cluster installation process. A minimum of 800 GB of storage is required to use a standard cluster.

If you deploy more compute machines, the OpenShift Container Platform cluster will use more storage.

Cluster limits
Available resources vary between clusters. The number of possible clusters within a vCenter is limited primarily by available storage space and any limitations on the number of required resources. Be sure to consider both limitations to the vCenter resources that the cluster creates and the resources that you require to deploy a cluster, such as IP addresses and networks.

Networking requirements
You must use the Dynamic Host Configuration Protocol (DHCP) for the network and ensure that the DHCP server is configured to provide persistent IP addresses to the cluster machines. In the DHCP lease, you must configure the DHCP to use the default gateway. All nodes must be in the same VLAN. You cannot scale the cluster using a second VLAN as a Day 2 operation. Additionally, you must create the following networking resources before you install the OpenShift Container Platform cluster:

NOTE

It is recommended that each OpenShift Container Platform node in the cluster must have access to a Network Time Protocol (NTP) server that is discoverable via DHCP. Installation is possible without an NTP server. However, asynchronous server clocks will cause errors, which NTP server prevents.

Required IP Addresses
An installer-provisioned vSphere installation requires two static IP addresses:

- The **API** address is used to access the cluster API.
- The **Ingress** address is used for cluster ingress traffic.

You must provide these IP addresses to the installation program when you install the OpenShift Container Platform cluster.

DNS records
You must create DNS records for two static IP addresses in the appropriate DNS server for the vCenter instance that hosts your OpenShift Container Platform cluster. In each record, **<cluster_name>** is the cluster name and **<base_domain>** is the cluster base domain that you specify when you install the cluster. A complete DNS record takes the form: **<component>.<cluster_name>.<base_domain>.**.

Table 21.8. Required DNS records

Component	Record	Description
API VIP	**api.<cluster_name>.<base_domain>.**	This DNS A/AAAA or CNAME record must point to the load balancer for the control plane machines. This record must be resolvable by both clients external to the cluster and from all the nodes within the cluster.

Component	Record	Description
Ingress VIP	***.apps.<cluster_name>.<base_domain>.**	A wildcard DNS A/AAAA or CNAME record that points to the load balancer that targets the machines that run the Ingress router pods, which are the worker nodes by default. This record must be resolvable by both clients external to the cluster and from all the nodes within the cluster.

21.2.7. Generating a key pair for cluster node SSH access

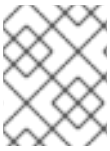
During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the **~/.ssh/authorized_keys** list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The **./openshift-install gather** command also requires the SSH public key to be in place on the cluster nodes.

IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.



NOTE

You must use a local key, not one that you configured with platform-specific approaches such as AWS key pairs.

Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N '' -f <path>/<file_name> 1
```

1. Specify the path and file name, such as **~/.ssh/id_ed25519**, of the new SSH key. If you have an existing key pair, ensure your public key is in the your **~/.ssh** directory.

NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS validated or Modules In Process cryptographic libraries on the **x86_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the ~/**.ssh/id_ed25519.pub** public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the **./openshift-install gather** command.

NOTE

On some distributions, default SSH private key identities such as ~/**.ssh/id_rsa** and ~/**.ssh/id_dsa** are managed automatically.

a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

Example output

```
Agent pid 31874
```

NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> (1)
```

(1) Specify the path and file name for your SSH private key, such as ~/**.ssh/id_ed25519**

Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

21.2.8. Obtaining the installation program

Before you install OpenShift Container Platform, download the installation file on a local computer.

Prerequisites

- You have a machine that runs Linux, for example Red Hat Enterprise Linux 8, with 500 MB of local disk space.

IMPORTANT

If you attempt to run the installation program on macOS, a known issue related to the **golang** compiler causes the installation of the OpenShift Container Platform cluster to fail. For more information about this issue, see the section named "Known Issues" in the *OpenShift Container Platform 4.11 release notes* document.

Procedure

1. Access the Infrastructure Provider page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program that corresponds with your host operating system and architecture, and place the file in the directory where you will store the installation configuration files.

IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.

IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation pull secret from the Red Hat OpenShift Cluster Manager . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

21.2.9. Adding vCenter root CA certificates to your system trust

Because the installation program requires access to your vCenter's API, you must add your vCenter's trusted root CA certificates to your system trust before you install an OpenShift Container Platform cluster.

Procedure

1. From the vCenter home page, download the vCenter's root CA certificates. Click **Download trusted root CA certificates** in the vSphere Web Services SDK section. The **<vCenter>/certs/download.zip** file downloads.

2. Extract the compressed file that contains the vCenter root CA certificates. The contents of the compressed file resemble the following file structure:

```
certs
├── lin
│   ├── 108f4d17.0
│   ├── 108f4d17.r1
│   ├── 7e757f6a.0
│   ├── 8e4f8471.0
│   └── 8e4f8471.r0
├── mac
│   ├── 108f4d17.0
│   ├── 108f4d17.r1
│   ├── 7e757f6a.0
│   ├── 8e4f8471.0
│   └── 8e4f8471.r0
└── win
    ├── 108f4d17.0.crt
    ├── 108f4d17.r1.crl
    ├── 7e757f6a.0.crt
    ├── 8e4f8471.0.crt
    └── 8e4f8471.r0.crl

3 directories, 15 files
```

3. Add the files for your operating system to the system trust. For example, on a Fedora operating system, run the following command:

```
# cp certs/lin/* /etc/pki/ca-trust/source/anchors
```

4. Update your system trust. For example, on a Fedora operating system, run the following command:

```
# update-ca-trust extract
```

21.2.10. Deploying the cluster

You can install OpenShift Container Platform on a compatible cloud platform.

IMPORTANT

You can run the **create cluster** command of the installation program only once, during initial installation.

Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.

Procedure

1. Change to the directory that contains the installation program and initialize the cluster deployment:

```
$ ./openshift-install create cluster --dir <installation_directory> \ 1
    --log-level=info 2
```

1 For **<installation_directory>**, specify the directory name to store the files that the installation program creates.

2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

When specifying the directory:

- Verify that the directory has the **execute** permission. This permission is required to run Terraform binaries under the installation directory.
- Use an empty directory. Some installation assets, such as bootstrap X.509 certificates, have short expiration intervals, therefore you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

2. Provide values at the prompts:

   a. Optional: Select an SSH key to use to access your cluster machines.

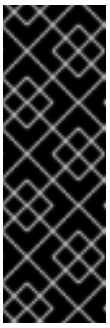
NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

   b. Select **vsphere** as the platform to target.

   c. Specify the name of your vCenter instance.

   d. Specify the user name and password for the vCenter account that has the required permissions to create the cluster.
   The installation program connects to your vCenter instance.



IMPORTANT

Some VMware vCenter Single Sign-On (SSO) environments with Active Directory (AD) integration might primarily require you to use the traditional login method, which requires the **<domain>**\ construct.

To ensure that vCenter account permission checks complete properly, consider using the User Principal Name (UPN) login method, such as **<username>@<fully_qualified_domainname>**.

e. Select the data center in your vCenter instance to connect to.

f. Select the datacenter in your vCenter instance to connect to.

g. Select the default vCenter datastore to use.

NOTE

Datastore and cluster names cannot exceed 60 characters; therefore, ensure the combined string length does not exceed the 60 character limit.

h. Select the vCenter cluster to install the OpenShift Container Platform cluster in. The installation program uses the root resource pool of the vSphere cluster as the default resource pool.

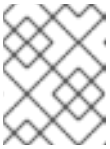
i. Select the network in the vCenter instance that contains the virtual IP addresses and DNS records that you configured.

j. Enter the virtual IP address that you configured for control plane API access.

k. Enter the virtual IP address that you configured for cluster ingress.

l. Enter the base domain. This base domain must be the same one that you used in the DNS records that you configured.

m. Enter a descriptive name for your cluster. The cluster name must be the same one that you used in the DNS records that you configured.



NOTE

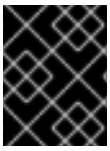
Datastore and cluster names cannot exceed 60 characters; therefore, ensure the combined string length does not exceed the 60 character limit.

n. Paste the pull secret from the Red Hat OpenShift Cluster Manager .

Verification

When the cluster deployment completes successfully:

- The terminal displays directions for accessing your cluster, including a link to the web console and credentials for the **kubeadmin** user.
- Credential information also outputs to **<installation_directory>/.openshift_install.log**.

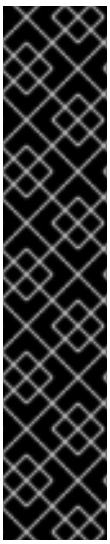


IMPORTANT

Do not delete the installation program or the files that the installation program creates. Both are required to delete the cluster.

Example output

```
...
INFO Install complete!
INFO To access the cluster as the system:admin user when using 'oc', run 'export
KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
INFO Access the OpenShift web-console here: https://console-openshift-
console.apps.mycluster.example.com
INFO Login to the console with user: "kubeadmin", and password: "password"
INFO Time elapsed: 36m22s
```



IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

21.2.11. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.

IMPORTANT

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.11. Download and install the new version of **oc**.

Installing the OpenShift CLI on Linux

You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the architecture in the **Product Variant** drop-down menu.
3. Select the appropriate version in the **Version** drop-down menu.

4. Click **Download Now** next to the **OpenShift v4.11 Linux Client** entry and save the file.
5. Unpack the archive:

```
$ tar xvf <file>
```

6. Place the **oc** binary in a directory that is on your **PATH**.
   To check your **PATH**, execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.
   To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
C:\> oc <command>
```

Installing the OpenShift CLI on macOS

You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 macOS Client** entry and save the file.

NOTE

For macOS arm64, choose the **OpenShift v4.11 macOS arm64 Client** entry.

4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your PATH.
   To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

21.2.12. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

Example output

```
system:admin
```

21.2.13. Creating registry storage

After you install the cluster, you must create storage for the registry Operator.

21.2.13.1. Image registry removed during installation

On platforms that do not provide shareable object storage, the OpenShift Image Registry Operator bootstraps itself as **Removed**. This allows **openshift-installer** to complete installations on these platform types.

After installation, you must edit the Image Registry Operator configuration to switch the **managementState** from **Removed** to **Managed**.

21.2.13.2. Image registry storage configuration

The Image Registry Operator is not initially available for platforms that do not provide default storage. After installation, you must configure your registry to use storage so that the Registry Operator is made available.

Instructions are shown for configuring a persistent volume, which is required for production clusters. Where applicable, instructions are shown for configuring an empty directory as the storage location, which is available for only non-production clusters.

Additional instructions are provided for allowing the image registry to use block storage types by using the **Recreate** rollout strategy during upgrades.

21.2.13.2.1. Configuring registry storage for VMware vSphere

As a cluster administrator, following installation you must configure your registry to use storage.

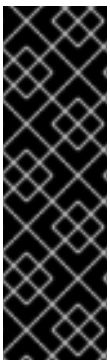
Prerequisites

- Cluster administrator permissions.
- A cluster on VMware vSphere.
- Persistent storage provisioned for your cluster, such as Red Hat OpenShift Data Foundation.

IMPORTANT

OpenShift Container Platform supports **ReadWriteOnce** access for image registry storage when you have only one replica. **ReadWriteOnce** access also requires that the registry uses the **Recreate** rollout strategy. To deploy an image registry that supports high availability with two or more replicas, **ReadWriteMany** access is required.

- Must have "100Gi" capacity.



IMPORTANT

Testing shows issues with using the NFS server on RHEL as storage backend for core services. This includes the OpenShift Container Registry and Quay, Prometheus for monitoring storage, and Elasticsearch for logging storage. Therefore, using RHEL NFS to back PVs used by core services is not recommended.

Other NFS implementations on the marketplace might not have these issues. Contact the individual NFS implementation vendor for more information on any testing that was possibly completed against these OpenShift Container Platform core components.

Procedure

1. To configure your registry to use storage, change the **spec.storage.pvc** in the **configs.imageregistry/cluster** resource.

NOTE

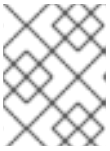
When you use shared storage, review your security settings to prevent outside access.

2. Verify that you do not have a registry pod:

```
$ oc get pod -n openshift-image-registry -l docker-registry=default
```

Example output

```
No resourses found in openshift-image-registry namespace
```



NOTE

If you do have a registry pod in your output, you do not need to continue with this procedure.

3. Check the registry configuration:

```
$ oc edit configs.imageregistry.operator.openshift.io
```

Example output

```
storage:
  pvc:
    claim: 1
```

1 Leave the **claim** field blank to allow the automatic creation of an **image-registry-storage** persistent volume claim (PVC). The PVC is generated based on the default storage class. However, be aware that the default storage class might provide ReadWriteOnce (RWO) volumes, such as a RADOS Block Device (RBD), which can cause issues when you replicate to more than one replica.

4. Check the **clusteroperator** status:

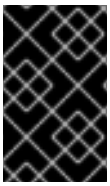
```
$ oc get clusteroperator image-registry
```

Example output

```
NAME             VERSION                             AVAILABLE   PROGRESSING   DEGRADED
SINCE   MESSAGE
image-registry   4.7                                 True        False         False      6h50m
```

21.2.13.2.2. Configuring block registry storage for VMware vSphere

To allow the image registry to use block storage types such as vSphere Virtual Machine Disk (VMDK) during upgrades as a cluster administrator, you can use the **Recreate** rollout strategy.



IMPORTANT

Block storage volumes are supported but not recommended for use with image registry on production clusters. An installation where the registry is configured on block storage is not highly available because the registry cannot have more than one replica.

Procedure

1. Enter the following command to set the image registry storage as a block storage type, patch the registry so that it uses the **Recreate** rollout strategy, and runs with only **1** replica:

```
$ oc patch config.imageregistry.operator.openshift.io/cluster --type=merge -p '{"spec":
{"rolloutStrategy":"Recreate","replicas":1}}'
```

2. Provision the PV for the block storage device, and create a PVC for that volume. The requested block volume uses the ReadWriteOnce (RWO) access mode.

   a. Create a **pvc.yaml** file with the following contents to define a VMware vSphere **PersistentVolumeClaim** object:

```
kind: PersistentVolumeClaim
apiVersion: v1
metadata:
  name: image-registry-storage 1
  namespace: openshift-image-registry 2
spec:
  accessModes:
  - ReadWriteOnce 3
  resources:
    requests:
      storage: 100Gi 4
```

   1. A unique name that represents the **PersistentVolumeClaim** object.
   2. The namespace for the **PersistentVolumeClaim** object, which is **openshift-image-registry**.
   3. The access mode of the persistent volume claim. With **ReadWriteOnce**, the volume can be mounted with read and write permissions by a single node.
   4. The size of the persistent volume claim.

   b. Enter the following command to create the **PersistentVolumeClaim** object from the file:

```
$ oc create -f pvc.yaml -n openshift-image-registry
```

3. Enter the following command to edit the registry configuration so that it references the correct PVC:

```
$ oc edit config.imageregistry.operator.openshift.io -o yaml
```

Example output

```
storage:
  pvc:
    claim: 1
```

1 By creating a custom PVC, you can leave the **claim** field blank for the default automatic creation of an **image-registry-storage** PVC.

For instructions about configuring registry storage so that it references the correct PVC, see Configuring the registry for vSphere.

21.2.14. Backing up VMware vSphere volumes

OpenShift Container Platform provisions new volumes as independent persistent disks to freely attach and detach the volume on any node in the cluster. As a consequence, it is not possible to back up volumes that use snapshots, or to restore volumes from snapshots. See Snapshot Limitations for more information.

Procedure

To create a backup of persistent volumes:

1. Stop the application that is using the persistent volume.
2. Clone the persistent volume.
3. Restart the application.
4. Create a backup of the cloned volume.
5. Delete the cloned volume.

21.2.15. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.11, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to OpenShift Cluster Manager Hybrid Cloud Console.

After you confirm that your OpenShift Cluster Manager Hybrid Cloud Console inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, use subscription watch to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

Additional resources

- See About remote health monitoring for more information about the Telemetry service

21.2.16. Configuring an external load balancer

You can configure an OpenShift Container Platform cluster to use an external load balancer in place of the default load balancer.

IMPORTANT

Configuring an external load balancer depends on your vendor's load balancer.

The information and examples in this section are for guideline purposes only. Consult the vendor documentation for more specific information about the vendor's load balancer.

Red Hat supports the following services for an external load balancer:

- Ingress Controller
- OpenShift API
- OpenShift MachineConfig API

You can choose whether you want to configure one or all of these services for an external load balancer. Configuring only the Ingress Controller service is a common configuration option. To better understand each service, view the following diagrams:

Figure 21.1. Example network workflow that shows an Ingress Controller operating in an OpenShift Container Platform environment

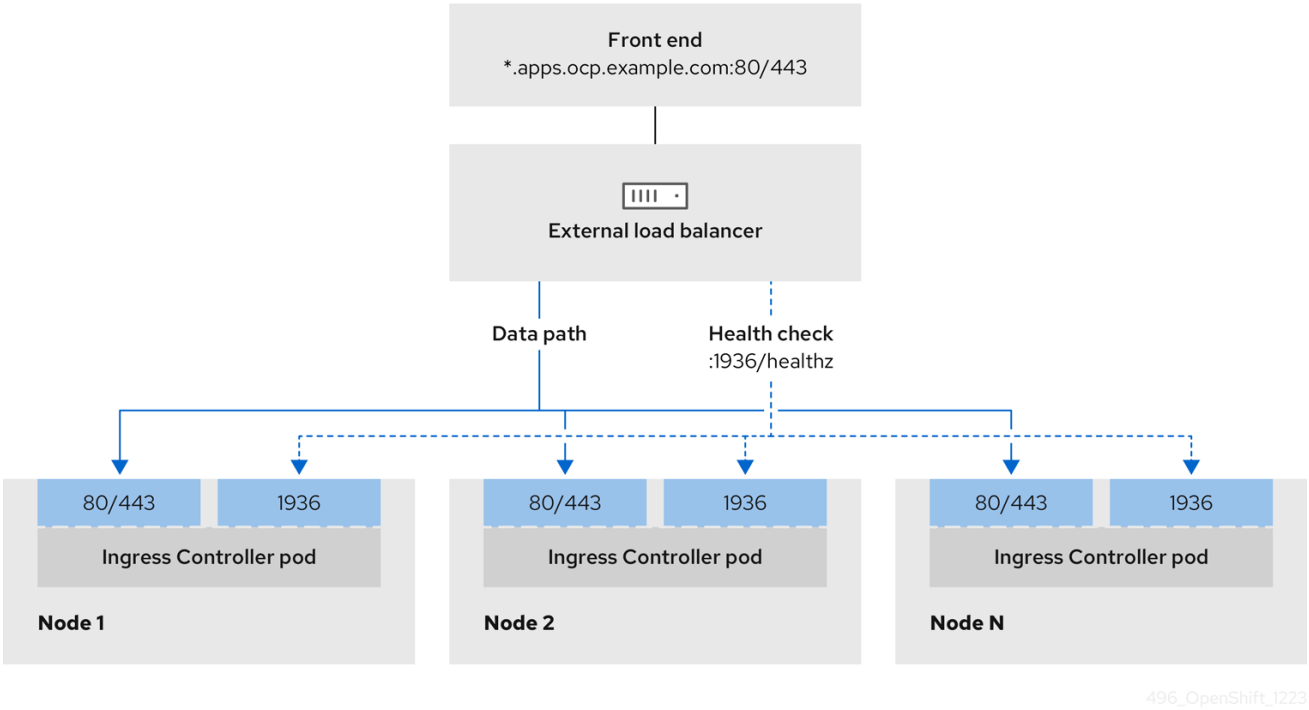


Figure 21.2. Example network workflow that shows an OpenShift API operating in an OpenShift Container Platform environment

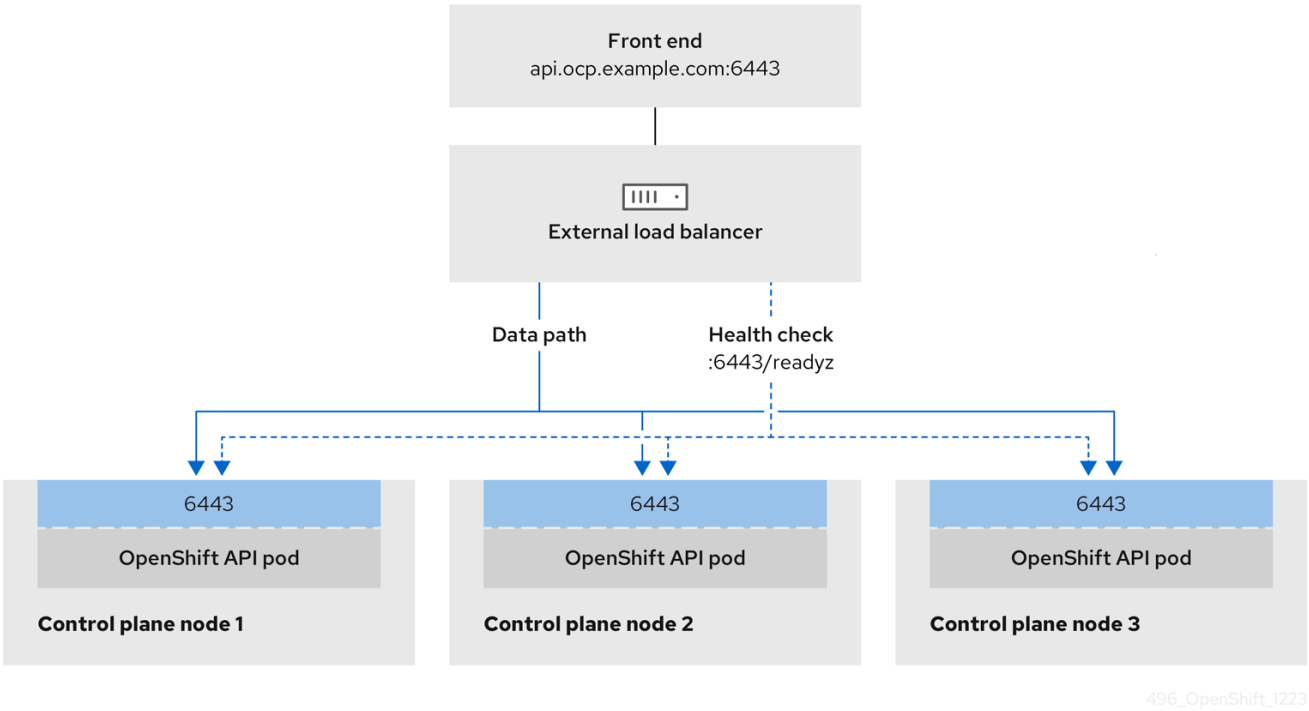
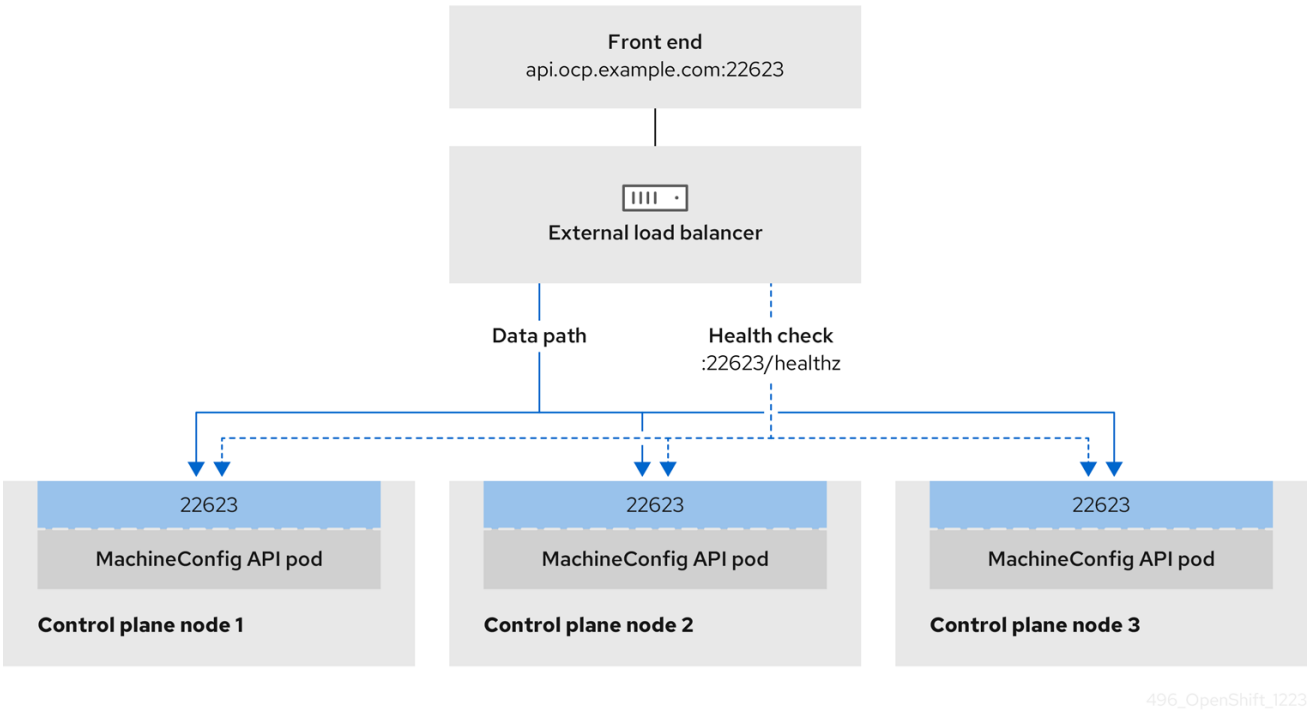


Figure 21.3. Example network workflow that shows an OpenShift MachineConfig API operating in an OpenShift Container Platform environment



Considerations

- For a front-end IP address, you can use the same IP address for the front-end IP address, the Ingress Controller's load balancer, and API load balancer. Check the vendor's documentation for this capability.

- For a back-end IP address, ensure that an IP address for an OpenShift Container Platform control plane node does not change during the lifetime of the external load balancer. You can achieve this by completing one of the following actions:
    - Assign a static IP address to each control plane node.
    - Configure each node to receive the same IP address from the DHCP every time the node requests a DHCP lease. Depending on the vendor, the DHCP lease might be in the form of an IP reservation or a static DHCP assignment.
- Manually define each node that runs the Ingress Controller in the external load balancer for the Ingress Controller back-end service. For example, if the Ingress Controller moves to an undefined node, a connection outage can occur.

OpenShift API prerequisites

- You defined a front-end IP address.
- TCP ports 6443 and 22623 are exposed on the front-end IP address of your load balancer. Check the following items:
    - Port 6443 provides access to the OpenShift API service.
    - Port 22623 can provide ignition startup configurations to nodes.
- The front-end IP address and port 6443 are reachable by all users of your system with a location external to your OpenShift Container Platform cluster.
- The front-end IP address and port 22623 are reachable only by OpenShift Container Platform nodes.
- The load balancer backend can communicate with OpenShift Container Platform control plane nodes on port 6443 and 22623.

Ingress Controller prerequisites

- You defined a front-end IP address.
- TCP ports 443 and 80 are exposed on the front-end IP address of your load balancer.
- The front-end IP address, port 80 and port 443 are be reachable by all users of your system with a location external to your OpenShift Container Platform cluster.
- The front-end IP address, port 80 and port 443 are reachable to all nodes that operate in your OpenShift Container Platform cluster.
- The load balancer backend can communicate with OpenShift Container Platform nodes that run the Ingress Controller on ports 80, 443, and 1936.

Prerequisite for health check URL specifications

You can configure most load balancers by setting health check URLs that determine if a service is available or unavailable. OpenShift Container Platform provides these health checks for the OpenShift API, Machine Configuration API, and Ingress Controller backend services.

The following examples demonstrate health check specifications for the previously listed backend services:

Example of a Kubernetes API health check specification

```
Path: HTTPS:6443/readyz
Healthy threshold: 2
Unhealthy threshold: 2
Timeout: 10
Interval: 10
```

Example of a Machine Config API health check specification

```
Path: HTTPS:22623/healthz
Healthy threshold: 2
Unhealthy threshold: 2
Timeout: 10
Interval: 10
```

Example of an Ingress Controller health check specification

```
Path: HTTP:1936/healthz/ready
Healthy threshold: 2
Unhealthy threshold: 2
Timeout: 5
Interval: 10
```

Procedure

1. Configure the HAProxy Ingress Controller, so that you can enable access to the cluster from your load balancer on ports 6443, 443, and 80:

   #### Example HAProxy configuration

   ```
   #...
   listen my-cluster-api-6443
       bind 192.168.1.100:6443
       mode tcp
       balance roundrobin
     option httpchk
     http-check connect
     http-check send meth GET uri /readyz
     http-check expect status 200
       server my-cluster-master-2 192.168.1.101:6443 check inter 10s rise 2 fall 2
       server my-cluster-master-0 192.168.1.102:6443 check inter 10s rise 2 fall 2
       server my-cluster-master-1 192.168.1.103:6443 check inter 10s rise 2 fall 2

   listen my-cluster-machine-config-api-22623
       bind 192.168.1.1000.0.0.0:22623
       mode tcp
       balance roundrobin
     option httpchk
     http-check connect
     http-check send meth GET uri /healthz
     http-check expect status 200
       server my-cluster-master-2 192.0168.21.2101:22623 check inter 10s rise 2 fall 2
       server my-cluster-master-0 192.168.1.1020.2.3:22623 check inter 10s rise 2 fall 2
   ```

```
    server my-cluster-master-1 192.168.1.1030.2.1:22623 check inter 10s rise 2 fall 2

listen my-cluster-apps-443
        bind 192.168.1.100:443
        mode tcp
        balance roundrobin
    option httpchk
    http-check connect
    http-check send meth GET uri /healthz/ready
    http-check expect status 200
        server my-cluster-worker-0 192.168.1.111:443 check port 1936 inter 10s rise 2 fall 2
        server my-cluster-worker-1 192.168.1.112:443 check port 1936 inter 10s rise 2 fall 2
        server my-cluster-worker-2 192.168.1.113:443 check port 1936 inter 10s rise 2 fall 2

listen my-cluster-apps-80
        bind 192.168.1.100:80
        mode tcp
        balance roundrobin
    option httpchk
    http-check connect
    http-check send meth GET uri /healthz/ready
    http-check expect status 200
        server my-cluster-worker-0 192.168.1.111:80 check port 1936 inter 10s rise 2 fall 2
        server my-cluster-worker-1 192.168.1.112:80 check port 1936 inter 10s rise 2 fall 2
        server my-cluster-worker-2 192.168.1.113:80 check port 1936 inter 10s rise 2 fall 2
# ...
```

2. Use the **curl** CLI command to verify that the external load balancer and its resources are operational:

   a. Verify that the cluster machine configuration API is accessible to the Kubernetes API server resource, by running the following command and observing the response:

      ```
      $ curl https://<loadbalancer_ip_address>:6443/version --insecure
      ```

      If the configuration is correct, you receive a JSON object in response:

      ```
      {
        "major": "1",
        "minor": "11+",
        "gitVersion": "v1.11.0+ad103ed",
        "gitCommit": "ad103ed",
        "gitTreeState": "clean",
        "buildDate": "2019-01-09T06:44:10Z",
        "goVersion": "go1.10.3",
        "compiler": "gc",
        "platform": "linux/amd64"
      }
      ```

   b. Verify that the cluster machine configuration API is accessible to the Machine config server resource, by running the following command and observing the output:

      ```
      $ curl -v https://<loadbalancer_ip_address>:22623/healthz --insecure
      ```

      If the configuration is correct, the output from the command shows the following response:

```
HTTP/1.1 200 OK
Content-Length: 0
```

c. Verify that the controller is accessible to the Ingress Controller resource on port 80, by running the following command and observing the output:

```
$ curl -I -L -H "Host: console-openshift-console.apps.<cluster_name>.<base_domain>"
http://<load_balancer_front_end_IP_address>
```

If the configuration is correct, the output from the command shows the following response:

```
HTTP/1.1 302 Found
content-length: 0
location: https://console-openshift-console.apps.ocp4.private.opequon.net/
cache-control: no-cache
```

d. Verify that the controller is accessible to the Ingress Controller resource on port 443, by running the following command and observing the output:

```
$ curl -I -L --insecure --resolve console-openshift-console.apps.<cluster_name>.
<base_domain>:443:<Load Balancer Front End IP Address> https://console-openshift-
console.apps.<cluster_name>.<base_domain>
```

If the configuration is correct, the output from the command shows the following response:

```
HTTP/1.1 200 OK
referrer-policy: strict-origin-when-cross-origin
set-cookie: csrf-
token=UlYWOyQ62LWjw2h003xtYSKlh1a0Py2hhctw0WmV2YEdhJjFyQwWcGBsja261dG
LgaYO0nxzVErhiXt6QepA7g==; Path=/; Secure; SameSite=Lax
x-content-type-options: nosniff
x-dns-prefetch-control: off
x-frame-options: DENY
x-xss-protection: 1; mode=block
date: Wed, 04 Oct 2023 16:29:38 GMT
content-type: text/html; charset=utf-8
set-cookie:
1e2670d92730b515ce3a1bb65da45062=1bf5e9573c9a2760c964ed1659cc1673; path=/;
HttpOnly; Secure; SameSite=None
cache-control: private
```

3. Configure the DNS records for your cluster to target the front-end IP addresses of the external load balancer. You must update records to your DNS server for the cluster API and applications over the load balancer.

Examples of modified DNS records

```
<load_balancer_ip_address>  A  api.<cluster_name>.<base_domain>
A record pointing to Load Balancer Front End
```

```
<load_balancer_ip_address>  A apps.<cluster_name>.<base_domain>
A record pointing to Load Balancer Front End
```

IMPORTANT

DNS propagation might take some time for each DNS record to become available. Ensure that each DNS record propagates before validating each record.

4. Use the **curl** CLI command to verify that the external load balancer and DNS record configuration are operational:

   a. Verify that you can access the cluster API, by running the following command and observing the output:

   ```
   $ curl https://api.<cluster_name>.<base_domain>:6443/version --insecure
   ```

   If the configuration is correct, you receive a JSON object in response:

   ```
   {
     "major": "1",
     "minor": "11+",
     "gitVersion": "v1.11.0+ad103ed",
     "gitCommit": "ad103ed",
     "gitTreeState": "clean",
     "buildDate": "2019-01-09T06:44:10Z",
     "goVersion": "go1.10.3",
     "compiler": "gc",
     "platform": "linux/amd64"
     }
   ```

   b. Verify that you can access the cluster machine configuration, by running the following command and observing the output:

   ```
   $ curl -v https://api.<cluster_name>.<base_domain>:22623/healthz --insecure
   ```

   If the configuration is correct, the output from the command shows the following response:

   ```
   HTTP/1.1 200 OK
   Content-Length: 0
   ```

   c. Verify that you can access each cluster application on port, by running the following command and observing the output:

   ```
   $ curl http://console-openshift-console.apps.<cluster_name>.<base_domain> -I -L --
   insecure
   ```

   If the configuration is correct, the output from the command shows the following response:

   ```
   HTTP/1.1 302 Found
   content-length: 0
   location: https://console-openshift-console.apps.<cluster-name>.<base domain>/
   cache-control: no-cacheHTTP/1.1 200 OK
   referrer-policy: strict-origin-when-cross-origin
   set-cookie: csrf-
   token=39HoZgztDnzjJkq/JuLJMeoKNXlfiVv2YgZc09c3TBOBU4NI6kDXaJH1LdicNhN1UsQ
   Wzon4Dor9GWGfopaTEQ==; Path=/; Secure
   ```

```
x-content-type-options: nosniff
x-dns-prefetch-control: off
x-frame-options: DENY
x-xss-protection: 1; mode=block
date: Tue, 17 Nov 2020 08:42:10 GMT
content-type: text/html; charset=utf-8
set-cookie:
1e2670d92730b515ce3a1bb65da45062=9b714eb87e93cf34853e87a92d6894be; path=/;
HttpOnly; Secure; SameSite=None
cache-control: private
```

d. Verify that you can access each cluster application on port 443, by running the following command and observing the output:

```
$ curl https://console-openshift-console.apps.<cluster_name>.<base_domain> -I -L --
insecure
```

If the configuration is correct, the output from the command shows the following response:

```
HTTP/1.1 200 OK
referrer-policy: strict-origin-when-cross-origin
set-cookie: csrf-
token=UlYWOyQ62LWjw2h003xtYSKlh1a0Py2hhctw0WmV2YEdhJjFyQwWcGBsja261dG
LgaYO0nxzVErhiXt6QepA7g==; Path=/; Secure; SameSite=Lax
x-content-type-options: nosniff
x-dns-prefetch-control: off
x-frame-options: DENY
x-xss-protection: 1; mode=block
date: Wed, 04 Oct 2023 16:29:38 GMT
content-type: text/html; charset=utf-8
set-cookie:
1e2670d92730b515ce3a1bb65da45062=1bf5e9573c9a2760c964ed1659cc1673; path=/;
HttpOnly; Secure; SameSite=None
cache-control: private
```

21.2.17. Next steps

- Customize your cluster.
- If necessary, you can opt out of remote health reporting .
- Set up your registry and configure registry storage .
- Optional: View the events from the vSphere Problem Detector Operator to determine if the cluster has permission or storage configuration issues.

21.3. INSTALLING A CLUSTER ON VSPHERE WITH CUSTOMIZATIONS

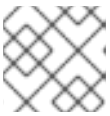
In OpenShift Container Platform version 4.11, you can install a cluster on your VMware vSphere instance by using installer-provisioned infrastructure. To customize the installation, you modify parameters in the **install-config.yaml** file before you install the cluster.

NOTE

OpenShift Container Platform supports deploying a cluster to a single VMware vCenter only. Deploying a cluster with machines/machine sets on multiple vCenters is not supported.

21.3.1. Prerequisites

- You reviewed details about the OpenShift Container Platform installation and update processes.
- You read the documentation on selecting a cluster installation method and preparing it for users.
- You provisioned persistent storage for your cluster. To deploy a private image registry, your storage must provide **ReadWriteMany** access modes.
- The OpenShift Container Platform installer requires access to port 443 on the vCenter and ESXi hosts. You verified that port 443 is accessible.
- If you use a firewall, you confirmed with the administrator that port 443 is accessible. Control plane nodes must be able to reach vCenter and ESXi hosts on port 443 for the installation to succeed.
- If you use a firewall, you configured it to allow the sites that your cluster requires access to.



NOTE

Be sure to also review this site list if you are configuring a proxy.

21.3.2. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.11, you require access to the internet to install your cluster.

You must have internet access to:

- Access OpenShift Cluster Manager Hybrid Cloud Console to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access Quay.io to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.

IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

21.3.3. VMware vSphere infrastructure requirements

You must install the OpenShift Container Platform cluster on a VMware vSphere version 7 instance that meets the requirements for the components that you use.

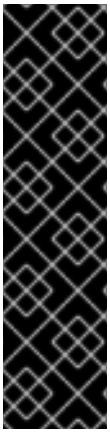
NOTE

OpenShift Container Platform version 4.11 does not support VMware vSphere version 8.0.

You can host the VMware vSphere infrastructure on-premise or on a VMware Cloud Verified provider that meets the requirements outlined in the following table:

Table 21.9. Version requirements for vSphere virtual environments

Virtual environment product	Required version
VM hardware version	15 or later
vSphere ESXi hosts	7
vCenter host	7



IMPORTANT

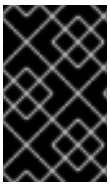
Installing a cluster on VMware vSphere version 7.0 Update 1 or earlier is now deprecated. These versions are still fully supported, but version 4.11 of OpenShift Container Platform requires vSphere virtual hardware version 15 or later. Hardware version 15 is now the default for vSphere virtual machines in OpenShift Container Platform. To update the hardware version for your vSphere nodes, see the "Updating hardware on nodes running in vSphere" article.

If your vSphere nodes are below hardware version 15 or your VMware vSphere version is earlier than 6.7.3, upgrading from OpenShift Container Platform 4.10 to OpenShift Container Platform 4.11 is not available.

Table 21.10. Minimum supported vSphere version for VMware components

Component	Minimum supported versions	Description
Hypervisor	vSphere 7 with HW version 15	This version is the minimum version that Red Hat Enterprise Linux CoreOS (RHCOS) supports. For more information about supported hardware on the latest version of Red Hat Enterprise Linux (RHEL) that is compatible with RHCOS, see Hardware on the Red Hat Customer Portal.

Component	Minimum supported versions	Description
Storage with in-tree drivers	vSphere 7	This plugin creates vSphere storage by using the in-tree storage drivers for vSphere included in OpenShift Container Platform.
Optional: Networking (NSX-T)	vSphere 7	vSphere 7 is required for OpenShift Container Platform. For more information about the compatibility of NSX and OpenShift Container Platform, see the Release Notes section of VMware's NSX container plugin documentation.



IMPORTANT

You must ensure that the time on your ESXi hosts is synchronized before you install OpenShift Container Platform. See Edit Time Configuration for a Host in the VMware documentation.

21.3.4. Network connectivity requirements

You must configure the network connectivity between machines to allow OpenShift Container Platform cluster components to communicate.

Review the following details about the required network ports.

Table 21.11. Ports used for all-machine to all-machine communications

Protocol	Port	Description
ICMP	N/A	Network reachability tests
TCP	**1936**	Metrics
	9000-**9999**	Host level services, including the node exporter on ports **9100**-**9101** and the Cluster Version Operator on port**9099**.
	10250-**10259**	The default ports that Kubernetes reserves
	10256	openshift-sdn
UDP	**4789**	virtual extensible LAN (VXLAN)
	6081	Geneve

Protocol	Port	Description
	9000-**9999**	Host level services, including the node exporter on ports **9100**-**9101**.
	500	IPsec IKE packets
	4500	IPsec NAT-T packets
TCP/UDP	**30000**-**32767**	Kubernetes node port
ESP	N/A	IPsec Encapsulating Security Payload (ESP)

Table 21.12. Ports used for all-machine to control plane communications

Protocol	Port	Description
TCP	**6443**	Kubernetes API

Table 21.13. Ports used for control plane machine to control plane machine communications

Protocol	Port	Description
TCP	**2379**-**2380**	etcd server and peer ports

21.3.5. VMware vSphere CSI Driver Operator requirements

To install the vSphere CSI Driver Operator, the following requirements must be met:

- VMware vSphere version 7.0 Update 1 or later
- Virtual machines of hardware version 15 or later
- No third-party vSphere CSI driver already installed in the cluster

IMPORTANT

If a third-party vSphere CSI driver is present in the cluster, OpenShift Container Platform does not overwrite it. If you continue with the third-party vSphere CSI driver when upgrading to the next major version of OpenShift Container Platform, the **oc** CLI prompts you with the following message:

```
VSphereCSIDriverOperatorCRUpgradeable: VMwareVSphereControllerUpgradeable:
found existing unsupported csi.vsphere.vmware.com driver
```

The previous message informs you that Red Hat does not support the third-party vSphere CSI driver during an OpenShift Container Platform upgrade operation. You can choose to ignore this message and continue with the upgrade operation.

Additional resources

- To remove a third-party vSphere CSI driver, see Removing a third-party vSphere CSI Driver .
- To update the hardware version for your vSphere nodes, see Updating hardware on nodes running in vSphere.

21.3.6. vCenter requirements

Before you install an OpenShift Container Platform cluster on your vCenter that uses infrastructure that the installer provisions, you must prepare your environment.

Required vCenter account privileges
To install an OpenShift Container Platform cluster in a vCenter, the installation program requires access to an account with privileges to read and create the required resources. Using an account that has global administrative privileges is the simplest way to access all of the necessary permissions.

If you cannot use an account with global administrative privileges, you must create roles to grant the privileges necessary for OpenShift Container Platform cluster installation. While most of the privileges are always required, some are required only if you plan for the installation program to provision a folder to contain the OpenShift Container Platform cluster on your vCenter instance, which is the default behavior. You must create or amend vSphere roles for the specified objects to grant the required privileges.

An additional role is required if the installation program is to create a vSphere virtual machine folder.

Example 21.4. Roles and privileges required for installation in vSphere API

vSphere object for role	When required	Required privileges in vSphere API
vSphere vCenter	Always	**Cns.Searchable** **InventoryService.Tagging.AttachTag** **InventoryService.Tagging.CreateCategory** **InventoryService.Tagging.CreateTag** **InventoryService.Tagging.DeleteCategory** **InventoryService.Tagging.DeleteTag** **InventoryService.Tagging.EditCategory** **InventoryService.Tagging.EditTag** **Sessions.ValidateSession** **StorageProfile.Update** **StorageProfile.View**

vSphere object for role	When required	Required privileges in vSphere API
vSphere vCenter Cluster	If VMs will be created in the cluster root	**Host.Config.Storage** **Resource.AssignVMToPool** **VApp.AssignResourcePool** **VApp.Import** **VirtualMachine.Config.AddNewDisk**
vSphere vCenter Resource Pool	If an existing resource pool is provided	**Host.Config.Storage** **Resource.AssignVMToPool** **VApp.AssignResourcePool** **VApp.Import** **VirtualMachine.Config.AddNewDisk**
vSphere Datastore	Always	**Datastore.AllocateSpace** **Datastore.Browse** **Datastore.FileManagement** **InventoryService.Tagging.ObjectAttachable**
vSphere Port Group	Always	**Network.Assign**
Virtual Machine Folder	Always	**InventoryService.Tagging.ObjectAttachable** **Resource.AssignVMToPool** **VApp.Import** **VirtualMachine.Config.AddExistingDisk** **VirtualMachine.Config.AddNewDisk** **VirtualMachine.Config.AddRemoveDevice** **VirtualMachine.Config.AdvancedConfig** **VirtualMachine.Config.Annotation** **VirtualMachine.Config.CPUCount** **VirtualMachine.Config.DiskExtend** **VirtualMachine.Config.DiskLease** **VirtualMachine.Config.EditDevice** **VirtualMachine.Config.Memory** **VirtualMachine.Config.RemoveDisk**

vSphere object for role	When required	Required privileges in vSphere API
		VirtualMachine.Config.Rename **VirtualMachine.Config.ResetGuestInfo** **VirtualMachine.Config.Resource** **VirtualMachine.Config.Settings** **VirtualMachine.Config.UpgradeVirtualHardware** **VirtualMachine.Interact.GuestControl** **VirtualMachine.Interact.PowerOff** **VirtualMachine.Interact.PowerOn** **VirtualMachine.Interact.Reset** **VirtualMachine.Inventory.Create** **VirtualMachine.Inventory.CreateFromExisting** **VirtualMachine.Inventory.Delete** **VirtualMachine.Provisioning.Clone** **VirtualMachine.Provisioning.MarkAsTemplate** **VirtualMachine.Provisioning.DeployTemplate**
vSphere vCenter Datacenter	If the installation program creates the virtual machine folder	**InventoryService.Tagging.ObjectAttachable** **Resource.AssignVMToPool** **VApp.Import** **VirtualMachine.Config.AddExistingDisk** **VirtualMachine.Config.AddNewDisk** **VirtualMachine.Config.AddRemoveDevice** **VirtualMachine.Config.AdvancedConfig** **VirtualMachine.Config.Annotation** **VirtualMachine.Config.CPUCount** **VirtualMachine.Config.DiskExtend** **VirtualMachine.Config.DiskLease** **VirtualMachine.Config.EditDevice** **VirtualMachine.Config.Memory** **VirtualMachine.Config.Rem**

vSphere object for role	When required	Required privileges in vSphere API
		oveDisk VirtualMachine.Config.Rena me VirtualMachine.Config.Reset GuestInfo VirtualMachine.Config.Resource VirtualMachine.Config.Settings VirtualMachine.Config.Upgr adeVirtualHardware VirtualMachine.Interact.Gue stControl VirtualMachine.Interact.Pow erOff VirtualMachine.Interact.Pow erOn VirtualMachine.Interact.Res et VirtualMachine.Inventory.Cr eate VirtualMachine.Inventory.Cr eateFromExisting VirtualMachine.Inventory.D elete VirtualMachine.Provisionin g.Clone VirtualMachine.Provisionin g.DeployTemplate VirtualMachine.Provisionin g.MarkAsTemplate Folder.Create Folder.Delete

Example 21.5. Roles and privileges required for installation in vCenter graphical user interface (GUI)

vSphere object for role	When required	Required privileges in vCenter GUI

vSphere object for role	When required	Required privileges in vCenter GUI
vSphere vCenter	Always	**Cns.Searchable "vSphere Tagging"."Assign or Unassign vSphere Tag" "vSphere Tagging"."Create vSphere Tag Category" "vSphere Tagging"."Create vSphere Tag" vSphere Tagging"."Delete vSphere Tag Category" "vSphere Tagging"."Delete vSphere Tag" "vSphere Tagging"."Edit vSphere Tag Category" "vSphere Tagging"."Edit vSphere Tag" Sessions."Validate session" "Profile-driven storage"."Profile-driven storage update" "Profile-driven storage"."Profile-driven storage view"**
vSphere vCenter Cluster	If VMs will be created in the cluster root	**Host.Configuration."Storage partition configuration" Resource."Assign virtual machine to resource pool" VApp."Assign resource pool" VApp.Import "Virtual machine"."Change Configuration"."Add new disk"**
vSphere vCenter Resource Pool	If an existing resource pool is provided	**Host.Configuration."Storage partition configuration" Resource."Assign virtual machine to resource pool" VApp."Assign resource pool" VApp.Import "Virtual machine"."Change Configuration"."Add new disk"**

vSphere object for role	When required	Required privileges in vCenter GUI
vSphere Datastore	Always	**Datastore."Allocate space" Datastore."Browse datastore" Datastore."Low level file operations" "vSphere Tagging"."Assign or Unassign vSphere Tag on Object"**
vSphere Port Group	Always	**Network."Assign network"**
Virtual Machine Folder	Always	**"vSphere Tagging"."Assign or Unassign vSphere Tag on Object" Resource."Assign virtual machine to resource pool" VApp.Import "Virtual machine"."Change Configuration"."Add existing disk" "Virtual machine"."Change Configuration"."Add new disk" "Virtual machine"."Change Configuration"."Add or remove device" "Virtual machine"."Change Configuration"."Advanced configuration" "Virtual machine"."Change Configuration"."Set annotation" "Virtual machine"."Change Configuration"."Change CPU count" "Virtual machine"."Change Configuration"."Extend virtual disk" "Virtual machine"."Change Configuration"."Acquire disk lease" "Virtual machine"."Change Configuration"."Modify device settings" "Virtual machine"."Change Configuration"."Change Memory" "Virtual machine"."Change Configuration"."Remove disk" "Virtual machine"."Change**

vSphere object for role	When required	Required privileges in vCenter GUI
		Configuration".Rename **Virtual machine"."Change Configuration"."Reset guest information"** **"Virtual machine"."Change Configuration"."Change resource"** **"Virtual machine"."Change Configuration"."Change Settings"** **"Virtual machine"."Change Configuration"."Upgrade virtual machine compatibility"** **"Virtual machine".Interaction."Guest operating system management by VIX API"** **"Virtual machine".Interaction."Power off"** **"Virtual machine".Interaction."Power on"** **"Virtual machine".Interaction.Reset** **"Virtual machine"."Edit Inventory"."Create new"** **"Virtual machine"."Edit Inventory"."Create from existing"** **"Virtual machine"."Edit Inventory"."Remove"** **"Virtual machine".Provisioning."Clone virtual machine"** **"Virtual machine".Provisioning."Mark as template"** **"Virtual machine".Provisioning."Deploy template"**
vSphere vCenter Datacenter	If the installation program creates the virtual machine folder	**"vSphere Tagging"."Assign or Unassign vSphere Tag on Object"** **Resource."Assign virtual machine to resource pool"** **VApp.Import** **"Virtual machine"."Change Configuration"."Add existing disk"** **"Virtual machine"."Change Configuration"."Add new disk"** **"Virtual machine"."Change**

vSphere object for role	When required	Required privileges in vCenter GUI
		Configuration"."Add or remove device" "Virtual machine"."Change Configuration"."Advanced configuration" "Virtual machine"."Change Configuration"."Set annotation" "Virtual machine"."Change Configuration"."Change CPU count" "Virtual machine"."Change Configuration"."Extend virtual disk" "Virtual machine"."Change Configuration"."Acquire disk lease" "Virtual machine"."Change Configuration"."Modify device settings" "Virtual machine"."Change Configuration"."Change Memory" "Virtual machine"."Change Configuration"."Remove disk" "Virtual machine"."Change Configuration".Rename "Virtual machine"."Change Configuration"."Reset guest information" "Virtual machine"."Change Configuration"."Change resource" "Virtual machine"."Change Configuration"."Change Settings" "Virtual machine"."Change Configuration"."Upgrade virtual machine compatibility" "Virtual machine".Interaction."Guest operating system management by VIX API" "Virtual machine".Interaction."Power off" "Virtual machine".Interaction."Power on" "Virtual machine".Interaction.Reset "Virtual machine"."Edit Inventory"."Create new" "Virtual machine"."Edit

vSphere object for role	When required	Required privileges in vCenter GUI
		Inventory"."Create from existing" Virtual machine"."Edit inventory"."Remove" "Virtual machine".Provisioning."Clone virtual machine" "Virtual machine".Provisioning."Deploy template" "Virtual machine".Provisioning."Mark as template" Folder."Create folder" Folder."Delete folder"

Additionally, the user requires some **ReadOnly** permissions, and some of the roles require permission to propogate the permissions to child objects. These settings vary depending on whether or not you install the cluster into an existing folder.

Example 21.6. Required permissions and propagation settings

vSphere object	When required	Propagate to children	Permissions required
vSphere vCenter	Always	False	Listed required privileges
vSphere vCenter Datacenter	Existing folder	False	**ReadOnly** permission
	Installation program creates the folder	True	Listed required privileges
vSphere vCenter Cluster	Existing resource pool	False	**ReadOnly** permission
	VMs in cluster root	True	Listed required privileges
vSphere vCenter Datastore	Always	False	Listed required privileges
vSphere Switch	Always	False	**ReadOnly** permission
vSphere Port Group	Always	False	Listed required privileges
vSphere vCenter Virtual Machine Folder	Existing folder	True	Listed required privileges

vSphere object	When required	Propagate to children	Permissions required
vSphere vCenter Resource Pool	Existing resource pool	True	Listed required privileges

For more information about creating an account with only the required privileges, see vSphere Permissions and User Management Tasks in the vSphere documentation.

Using OpenShift Container Platform with vMotion
If you intend on using vMotion in your vSphere environment, consider the following before installing a OpenShift Container Platform cluster.

- OpenShift Container Platform generally supports compute-only vMotion, where *generally* implies that you meet all VMware best practices for vMotion.
  To help ensure the uptime of your compute and control plane nodes, ensure that you follow the VMware best practices for vMotion, and use VMware anti-affinity rules to improve the availability of OpenShift Container Platform during maintenance or hardware issues.

  For more information about vMotion and anti-affinity rules, see the VMware vSphere documentation for vMotion networking requirements and VM anti-affinity rules.

- Using Storage vMotion can cause issues and is not supported. If you are using vSphere volumes in your pods, migrating a VM across datastores, either manually or through Storage vMotion, causes invalid references within OpenShift Container Platform persistent volume (PV) objects that can result in data loss.

- OpenShift Container Platform does not support selective migration of VMDKs across datastores, using datastore clusters for VM provisioning or for dynamic or static provisioning of PVs, or using a datastore that is part of a datastore cluster for dynamic or static provisioning of PVs.

Cluster resources
When you deploy an OpenShift Container Platform cluster that uses installer-provisioned infrastructure, the installation program must be able to create several resources in your vCenter instance.

A standard OpenShift Container Platform installation creates the following vCenter resources:

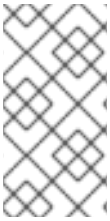
- 1 Folder
- 1 Tag category
- 1 Tag
- Virtual machines:
  - 1 template
  - 1 temporary bootstrap node
  - 3 control plane nodes
  - 3 compute machines

Although these resources use 856 GB of storage, the bootstrap node is destroyed during the cluster installation process. A minimum of 800 GB of storage is required to use a standard cluster.

If you deploy more compute machines, the OpenShift Container Platform cluster will use more storage.

Cluster limits
Available resources vary between clusters. The number of possible clusters within a vCenter is limited primarily by available storage space and any limitations on the number of required resources. Be sure to consider both limitations to the vCenter resources that the cluster creates and the resources that you require to deploy a cluster, such as IP addresses and networks.

Networking requirements
You must use the Dynamic Host Configuration Protocol (DHCP) for the network and ensure that the DHCP server is configured to provide persistent IP addresses to the cluster machines. In the DHCP lease, you must configure the DHCP to use the default gateway. All nodes must be in the same VLAN. You cannot scale the cluster using a second VLAN as a Day 2 operation. Additionally, you must create the following networking resources before you install the OpenShift Container Platform cluster:



NOTE

It is recommended that each OpenShift Container Platform node in the cluster must have access to a Network Time Protocol (NTP) server that is discoverable via DHCP. Installation is possible without an NTP server. However, asynchronous server clocks will cause errors, which NTP server prevents.

Required IP Addresses
An installer-provisioned vSphere installation requires two static IP addresses:

- The **API** address is used to access the cluster API.
- The **Ingress** address is used for cluster ingress traffic.

You must provide these IP addresses to the installation program when you install the OpenShift Container Platform cluster.

DNS records
You must create DNS records for two static IP addresses in the appropriate DNS server for the vCenter instance that hosts your OpenShift Container Platform cluster. In each record, **<cluster_name>** is the cluster name and **<base_domain>** is the cluster base domain that you specify when you install the cluster. A complete DNS record takes the form: **<component>.<cluster_name>.<base_domain>.**.

Table 21.14. Required DNS records

Component	Record	Description
API VIP	**api.<cluster_name>.<base_domain>.**	This DNS A/AAAA or CNAME record must point to the load balancer for the control plane machines. This record must be resolvable by both clients external to the cluster and from all the nodes within the cluster.

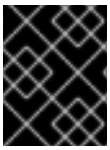
Component	Record	Description
Ingress VIP	***.apps.<cluster_name>.<base_domain>.**	A wildcard DNS A/AAAA or CNAME record that points to the load balancer that targets the machines that run the Ingress router pods, which are the worker nodes by default. This record must be resolvable by both clients external to the cluster and from all the nodes within the cluster.

21.3.7. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the **~/.ssh/authorized_keys** list for the **core** user on each node, which enables password-less authentication.

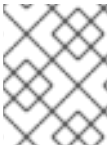
After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The **./openshift-install gather** command also requires the SSH public key to be in place on the cluster nodes.



IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.



NOTE

You must use a local key, not one that you configured with platform-specific approaches such as AWS key pairs.

Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N '' -f <path>/<file_name> 1
```

1 Specify the path and file name, such as **~/.ssh/id_ed25519**, of the new SSH key. If you have an existing key pair, ensure your public key is in the your **~/.ssh** directory.

NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS validated or Modules In Process cryptographic libraries on the **x86_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the ~/**.ssh/id_ed25519.pub** public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the **./openshift-install gather** command.

NOTE

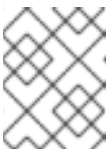
On some distributions, default SSH private key identities such as ~/**.ssh/id_rsa** and ~/**.ssh/id_dsa** are managed automatically.

a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

Example output

```
Agent pid 31874
```



NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> (1)
```

(1) Specify the path and file name for your SSH private key, such as ~/**.ssh/id_ed25519**

Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

Next steps

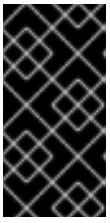
- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

21.3.8. Obtaining the installation program

Before you install OpenShift Container Platform, download the installation file on a local computer.

Prerequisites

- You have a machine that runs Linux, for example Red Hat Enterprise Linux 8, with 500 MB of local disk space.

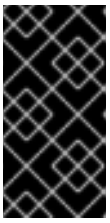


IMPORTANT

If you attempt to run the installation program on macOS, a known issue related to the **golang** compiler causes the installation of the OpenShift Container Platform cluster to fail. For more information about this issue, see the section named "Known Issues" in the *OpenShift Container Platform 4.11 release notes* document.

Procedure

1. Access the Infrastructure Provider page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program that corresponds with your host operating system and architecture, and place the file in the directory where you will store the installation configuration files.



IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.

IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation pull secret from the Red Hat OpenShift Cluster Manager . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

21.3.9. Adding vCenter root CA certificates to your system trust

Because the installation program requires access to your vCenter's API, you must add your vCenter's trusted root CA certificates to your system trust before you install an OpenShift Container Platform cluster.

Procedure

1. From the vCenter home page, download the vCenter's root CA certificates. Click **Download trusted root CA certificates** in the vSphere Web Services SDK section. The **<vCenter>/certs/download.zip** file downloads.

2. Extract the compressed file that contains the vCenter root CA certificates. The contents of the compressed file resemble the following file structure:

```
certs
├── lin
│   ├── 108f4d17.0
│   ├── 108f4d17.r1
│   ├── 7e757f6a.0
│   ├── 8e4f8471.0
│   └── 8e4f8471.r0
├── mac
│   ├── 108f4d17.0
│   ├── 108f4d17.r1
│   ├── 7e757f6a.0
│   ├── 8e4f8471.0
│   └── 8e4f8471.r0
└── win
    ├── 108f4d17.0.crt
    ├── 108f4d17.r1.crl
    ├── 7e757f6a.0.crt
    ├── 8e4f8471.0.crt
    └── 8e4f8471.r0.crl

3 directories, 15 files
```

3. Add the files for your operating system to the system trust. For example, on a Fedora operating system, run the following command:

```
# cp certs/lin/* /etc/pki/ca-trust/source/anchors
```

4. Update your system trust. For example, on a Fedora operating system, run the following command:

```
# update-ca-trust extract
```

21.3.10. Creating the installation configuration file

You can customize the OpenShift Container Platform cluster you install on VMware vSphere.

Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.
- Obtain service principal permissions at the subscription level.

Procedure

1. Create the **install-config.yaml** file.
   a. Change to the directory that contains the installation program and run the following command:

```
$ ./openshift-install create install-config --dir <installation_directory> 1
```

   1 For **<installation_directory>**, specify the directory name to store the files that the installation program creates.

   When specifying the directory:

   - Verify that the directory has the **execute** permission. This permission is required to run Terraform binaries under the installation directory.
   - Use an empty directory. Some installation assets, such as bootstrap X.509 certificates, have short expiration intervals, therefore you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

   b. At the prompts, provide the configuration details for your cloud:
      i. Optional: Select an SSH key to use to access your cluster machines.

NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

      ii. Select **vsphere** as the platform to target.
      iii. Specify the name of your vCenter instance.
      iv. Specify the user name and password for the vCenter account that has the required permissions to create the cluster.
      The installation program connects to your vCenter instance.
      v. Select the datacenter in your vCenter instance to connect to.
      vi. Select the default vCenter datastore to use.
      vii. Select the vCenter cluster to install the OpenShift Container Platform cluster in. The installation program uses the root resource pool of the vSphere cluster as the default resource pool.

viii. Select the network in the vCenter instance that contains the virtual IP addresses and DNS records that you configured.

ix. Enter the virtual IP address that you configured for control plane API access.

x. Enter the virtual IP address that you configured for cluster ingress.

xi. Enter the base domain. This base domain must be the same one that you used in the DNS records that you configured.

xii. Enter a descriptive name for your cluster. The cluster name you enter must match the cluster name you specified when configuring the DNS records.

xiii. Paste the pull secret from the Red Hat OpenShift Cluster Manager .

2. Modify the **install-config.yaml** file. You can find more information about the available parameters in the "Installation configuration parameters" section.

3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.

IMPORTANT

The **install-config.yaml** file is consumed during the installation process. If you want to reuse the file, you must back it up now.

21.3.10.1. Installation configuration parameters

Before you deploy an OpenShift Container Platform cluster, you provide parameter values to describe your account on the cloud platform that hosts your cluster and optionally customize your cluster's platform. When you create the **install-config.yaml** installation configuration file, you provide values for the required parameters through the command line. If you customize your cluster, you can modify the **install-config.yaml** file to provide more details about the platform.

NOTE

After installation, you cannot modify these parameters in the **install-config.yaml** file.

21.3.10.1.1. Required configuration parameters

Required installation configuration parameters are described in the following table:

Table 21.15. Required parameters

Parameter	Description	Values
apiVersion	The API version for the **install-config.yaml** content. The current version is **v1**. The installer may also support older API versions.	String

Parameter	Description	Values
baseDomain	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the **baseDomain** and **metadata.name** parameter values that uses the **<metadata.name>.<baseDomain>** format.	A fully-qualified domain or subdomain name, such as **example.com**.
metadata	Kubernetes resource **ObjectMeta**, from which only the **name** parameter is consumed.	Object
metadata.name	The name of the cluster. DNS records for the cluster are all subdomains of **{{.metadata.name}}.{{.baseDomain}}**.	String of lowercase letters and hyphens (**-**), such as **dev**.
platform	The configuration for the specific platform upon which to perform the installation: **alibabacloud**, **aws**, **baremetal**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**. For additional information about **platform.<platform>** parameters, consult the table for your specific platform that follows.	Object
pullSecret	Get a pull secret from the Red Hat OpenShift Cluster Manager to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	<pre>{ "auths":{ "cloud.openshift.com":{ "auth":"b3Blb=", "email":"you@example.com" }, "quay.io":{ "auth":"b3Blb=", "email":"you@example.com" } } }</pre>

21.3.10.1.2. Network configuration parameters

You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

Only IPv4 addresses are supported.

NOTE

Globalnet is not supported with Red Hat OpenShift Data Foundation disaster recovery solutions. For regional disaster recovery scenarios, ensure that you use a nonoverlapping range of private IP addresses for the cluster and service networks in each cluster.

Table 21.16. Network parameters

Parameter	Description	Values
networking	The configuration for the cluster network.	Object  NOTE You cannot modify parameters specified by the **networking** object after installation.
networking.networkType	The cluster network provider Container Network Interface (CNI) cluster network provider to install.	Either **OpenShiftSDN** or **OVNKubernetes**. **OpenShiftSDN** is a CNI provider for all-Linux networks. **OVNKubernetes** is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is **OpenShiftSDN**.
networking.clusterNetwork	The IP address blocks for pods. The default value is **10.128.0.0/14** with a host prefix of **/23**. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: `networking:` `  clusterNetwork:` `  - cidr: 10.128.0.0/14` `  hostPrefix: 23`
networking.clusterNetwork.cidr	Required if you use **networking.clusterNetwork**. An IP address block. An IPv4 network.	An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between **0** and **32**.

Parameter	Description	Values
networking.clusterNetwork.hostPrefix	The subnet prefix length to assign to each individual node. For example, if **hostPrefix** is set to **23** then each node is assigned a /**23** subnet out of the given **cidr**. A **hostPrefix** value of **23** provides 510 (2^(32 - 23) - 2) pod IP addresses.	A subnet prefix. The default value is **23**.
networking.serviceNetwork	The IP address block for services. The default value is **172.30.0.0/16**. The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.	An array with an IP address block in CIDR format. For example: networking: serviceNetwork: - 172.30.0.0/16
networking.machineNetwork	The IP address blocks for machines. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: networking: machineNetwork: - cidr: 10.0.0.0/16
networking.machineNetwork.cidr	Required if you use **networking.machineNetwork**. An IP address block. The default value is **10.0.0.0/16** for all platforms other than libvirt. For libvirt, the default value is **192.168.126.0/24**.	An IP network block in CIDR notation. For example, **10.0.0.0/16**. **NOTE** Set the **networking.machineNetwork** to match the CIDR that the preferred NIC resides in.

21.3.10.1.3. Optional configuration parameters

Optional installation configuration parameters are described in the following table:

Table 21.17. Optional parameters

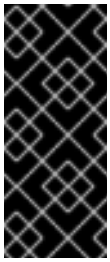
Parameter	Description	Values
additionalTrustBundle	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String

Parameter	Description	Values
capabilities	Controls the installation of optional core cluster components. You can reduce the footprint of your OpenShift Container Platform cluster by disabling optional components.	String array
capabilities.baselineCapabilitySet	Selects an initial set of optional capabilities to enable. Valid values are **None**, **v4.11** and **vCurrent**. **v4.11** enables the **baremetal** Operator, the **marketplace** Operator, and the **openshift-samples** content. **vCurrent** installs the recommended set of capabilities for the current version of OpenShift Container Platform. The default value is **vCurrent**.	String
capabilities.additionalEnabledCapabilities	Extends the set of optional capabilities beyond what you specify in **baselineCapabilitySet**. Valid values are **baremetal**, **marketplace** and **openshift-samples**. You may specify multiple capabilities in this parameter.	String array
cgroupsV2	Enables Linux control groups version 2 (cgroups v2) on specific nodes in your cluster. The OpenShift Container Platform process for enabling cgroups v2 disables all cgroup version 1 controllers and hierarchies. The OpenShift Container Platform cgroups version 2 feature is in Developer Preview and is not supported by Red Hat at this time.	**true**
compute	The configuration for the machines that comprise the compute nodes.	Array of **MachinePool** objects.
compute.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** (the default).	String
compute.name	Required if you use **compute**. The name of the machine pool.	**worker**

Parameter	Description	Values
compute.platform	Required if you use **compute**. Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the **controlPlane.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
compute.replicas	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to **2**. The default value is **3**.
controlPlane	The configuration for the machines that comprise the control plane.	Array of **MachinePool** objects.
controlPlane.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** (the default).	String
controlPlane.name	Required if you use **controlPlane**. The name of the machine pool.	**master**
controlPlane.platform	Required if you use **controlPlane**. Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the **compute.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
controlPlane.replicas	The number of control plane machines to provision.	The only supported value is **3**, which is the default value.

Parameter	Description	Values
credentialsMode	The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported.  **NOTE** Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the *Cloud Credential Operator* entry in the *Cluster Operators reference* content.  **NOTE** If your AWS account has service control policies (SCP) enabled, you must configure the **credentialsMode** parameter to **Mint**, **Passthrough** or **Manual**.	**Mint**, **Passthrough**, **Manual** or an empty string (**""**).

Parameter	Description	Values
fips	Enable or disable FIPS mode. The default is **false** (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.  **IMPORTANT** To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.  **NOTE** If you are using Azure File storage, you cannot enable FIPS mode.	**false** or **true**
imageContentSources	Sources and repositories for the release-image content.	Array of objects. Includes a **source** and, optionally, **mirrors**, as described in the following rows of this table.
imageContentSources.source	Required if you use **imageContentSources**. Specify the repository that users refer to, for example, in image pull specifications.	String
imageContentSources.mirrors	Specify one or more repositories that may also contain the same images.	Array of strings

Parameter	Description	Values
publish	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	**Internal** or **External**. The default value is **External**. Setting this field to **Internal** is not supported on non-cloud platforms and IBM Cloud VPC.  **IMPORTANT** If the value of the field is set to **Internal**, the cluster will become non-functional. For more information, refer to BZ#1953035.
sshKey	The SSH key to authenticate access to your cluster machines.  **NOTE** For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.	For example, **sshKey: ssh-ed25519 AAAA..**.

21.3.10.1.4. Additional VMware vSphere configuration parameters

Additional VMware vSphere configuration parameters are described in the following table:

Table 21.18. Additional VMware vSphere cluster parameters

Parameter	Description	Values
platform: vsphere vCenter	The fully-qualified hostname or IP address of the vCenter server.	String
platform: vsphere username	The user name to use to connect to the vCenter instance with. This user must have at least the roles and privileges that are required for static or dynamic persistent volume provisioning in vSphere.	String

Parameter	Description	Values
platform: vsphere password	The password for the vCenter user name.	String
platform: vsphere datacenter	The name of the datacenter to use in the vCenter instance.	String
platform: vsphere defaultDatastore	The name of the default datastore to use for provisioning volumes.	String
platform: vsphere folder	Optional. The absolute path of an existing folder where the installation program creates the virtual machines. If you do not provide this value, the installation program creates a folder that is named with the infrastructure ID in the datacenter virtual machine folder.	String, for example, **/<datacenter_name>/vm/<folder_name>/<subfolder_name>**.
platform: vsphere resourcePool	Optional. The absolute path of an existing resource pool where the installer creates the virtual machines. If you do not specify a value, resources are installed in the root of the cluster **/<datacenter_name>/host/<cluster_name>/Resources**.	String, for example, **/<datacenter_name>/host/<cluster_name>/Resources/<resource_pool_name>/<optional_nested_resource_pool_name>**.
platform: vsphere network	The network in the vCenter instance that contains the virtual IP addresses and DNS records that you configured.	String
platform: vsphere cluster	The vCenter cluster to install the OpenShift Container Platform cluster in.	String
platform: vsphere apiVIP	The virtual IP (VIP) address that you configured for control plane API access.	An IP address, for example **128.0.0.1**.

Parameter	Description	Values
platform: vsphere ingressVIP	The virtual IP (VIP) address that you configured for cluster ingress.	An IP address, for example **128.0.0.1**.
platform: vsphere diskType	Optional. The disk provisioning method. This value defaults to the vSphere default storage policy if not set.	Valid values are **thin**, **thick**, or **eagerZeroedThick**.

21.3.10.1.5. Optional VMware vSphere machine pool configuration parameters

Optional VMware vSphere machine pool configuration parameters are described in the following table:

Table 21.19. Optional VMware vSphere machine pool parameters

Parameter	Description	Values
platform: vsphere clusterOSImage	The location from which the installer downloads the RHCOS image. You must set this parameter to perform an installation in a restricted network.	An HTTP or HTTPS URL, optionally with a SHA-256 checksum. For example, **https://mirror.openshift.com/images/rhcos-<version>-vmware.<architecture>.ova**.
platform vsphere osDisk diskSizeGB	The size of the disk in gigabytes.	Integer
platform vsphere cpus	The total number of virtual processor cores to assign a virtual machine. The value of **platform.vsphere.cpus** must be a multiple of **platform.vsphere.coresPerSocket** value.	Integer
platform vsphere coresPerSocket	The number of cores per socket in a virtual machine. The number of virtual sockets on the virtual machine is **platform.vsphere.cpus**/**platform.vsphere.coresPerSocket**. The default value for control plane nodes and worker nodes is **4** and **2**, respectively.	Integer

Parameter	Description	Values
platform vsphere memoryMB	The size of a virtual machine's memory in megabytes.	Integer

21.3.10.2. Sample install-config.yaml file for an installer-provisioned VMware vSphere cluster

You can customize the install-config.yaml file to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.

```
apiVersion: v1
baseDomain: example.com (1)
compute: (2)
  name: worker
  replicas: 3
  platform:
    vsphere: (3)
      cpus: 2
      coresPerSocket: 2
      memoryMB: 8192
      osDisk:
        diskSizeGB: 120
controlPlane: (4)
  name: master
  replicas: 3
  platform:
    vsphere: (5)
      cpus: 4
      coresPerSocket: 2
      memoryMB: 16384
      osDisk:
        diskSizeGB: 120
metadata:
  name: cluster (6)
platform:
  vsphere:
    vcenter: your.vcenter.server
    username: username
    password: password
    datacenter: datacenter
    defaultDatastore: datastore
    folder: folder
    resourcePool: resource_pool (7)
    diskType: thin (8)
    network: VM_Network
    cluster: vsphere_cluster_name (9)
    apiVIP: api_vip
    ingressVIP: ingress_vip
```

```
fips: false
pullSecret: '{"auths": ...}'
sshKey: 'ssh-ed25519 AAAA...'
```

1. The base domain of the cluster. All DNS records must be sub-domains of this base and include the cluster name.

2 4. The **controlPlane** section is a single mapping, but the **compute** section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, **-**, and the first line of the **controlPlane** section must not. Only one control plane pool is used.

3 5. Optional: Provide additional configuration for the machine pool parameters for the compute and control plane machines.

6. The cluster name that you specified in your DNS records.

7. Optional: Provide an existing resource pool for machine creation. If you do not specify a value, the installation program uses the root resource pool of the vSphere cluster.

8. The vSphere disk provisioning method.

9. The vSphere cluster to install the OpenShift Container Platform cluster in.

21.3.10.3. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.

NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
```

1. A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
2. A proxy URL to use for creating HTTPS connections outside the cluster.
3. A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use * to bypass the proxy for all destinations. You must include vCenter's IP address and the IP range that you use for its machines.
4. If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace that contains one or more additional CA certificates that are required for proxying HTTPS connections. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges these contents with the Red Hat Enterprise Linux CoreOS (RHCOS) trust bundle, and this config map is referenced in the **trustedCA** field of the **Proxy** object. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.

NOTE

The installation program does not support the proxy **readinessEndpoints** field.

NOTE

If the installer times out, restart and then complete the deployment by using the **wait-for** command of the installer. For example:

```
$ ./openshift-install wait-for install-complete --log-level debug
```

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.

NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

21.3.11. Deploying the cluster

You can install OpenShift Container Platform on a compatible cloud platform.

IMPORTANT

You can run the **create cluster** command of the installation program only once, during initial installation.

Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.

Procedure

- Change to the directory that contains the installation program and initialize the cluster deployment:

```
$ ./openshift-install create cluster --dir <installation_directory> \ 1
    --log-level=info 2
```

1 For **<installation_directory>**, specify the location of your customized **./install-config.yaml** file.

2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

Verification

When the cluster deployment completes successfully:

- The terminal displays directions for accessing your cluster, including a link to the web console and credentials for the **kubeadmin** user.
- Credential information also outputs to **<installation_directory>/.openshift_install.log**.

IMPORTANT

Do not delete the installation program or the files that the installation program creates. Both are required to delete the cluster.

Example output

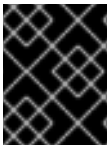
```
...
INFO Install complete!
INFO To access the cluster as the system:admin user when using 'oc', run 'export
KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
INFO Access the OpenShift web-console here: https://console-openshift-
console.apps.mycluster.example.com
INFO Login to the console with user: "kubeadmin", and password: "password"
INFO Time elapsed: 36m22s
```

IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

21.3.12. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.



IMPORTANT

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.11. Download and install the new version of **oc**.

Installing the OpenShift CLI on Linux

You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the architecture in the **Product Variant** drop-down menu.
3. Select the appropriate version in the **Version** drop-down menu.
4. Click **Download Now** next to the **OpenShift v4.11 Linux Client** entry and save the file.
5. Unpack the archive:

```
$ tar xvf <file>
```

6. Place the **oc** binary in a directory that is on your **PATH**.
   To check your **PATH**, execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.
   To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
C:\> oc <command>
```

Installing the OpenShift CLI on macOS

You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 macOS Client** entry and save the file.

NOTE

For macOS arm64, choose the **OpenShift v4.11 macOS arm64 Client** entry.

4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your PATH.
   To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

21.3.13. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

Example output

```
system:admin
```

21.3.14. Creating registry storage

After you install the cluster, you must create storage for the registry Operator.

21.3.14.1. Image registry removed during installation

On platforms that do not provide shareable object storage, the OpenShift Image Registry Operator bootstraps itself as **Removed**. This allows **openshift-installer** to complete installations on these platform types.

After installation, you must edit the Image Registry Operator configuration to switch the **managementState** from **Removed** to **Managed**.

21.3.14.2. Image registry storage configuration

The Image Registry Operator is not initially available for platforms that do not provide default storage. After installation, you must configure your registry to use storage so that the Registry Operator is made available.

Instructions are shown for configuring a persistent volume, which is required for production clusters. Where applicable, instructions are shown for configuring an empty directory as the storage location, which is available for only non-production clusters.

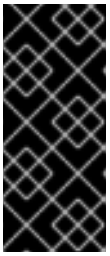
Additional instructions are provided for allowing the image registry to use block storage types by using the **Recreate** rollout strategy during upgrades.

21.3.14.2.1. Configuring registry storage for VMware vSphere

As a cluster administrator, following installation you must configure your registry to use storage.

Prerequisites

- Cluster administrator permissions.
- A cluster on VMware vSphere.
- Persistent storage provisioned for your cluster, such as Red Hat OpenShift Data Foundation.



IMPORTANT

OpenShift Container Platform supports **ReadWriteOnce** access for image registry storage when you have only one replica. **ReadWriteOnce** access also requires that the registry uses the **Recreate** rollout strategy. To deploy an image registry that supports high availability with two or more replicas, **ReadWriteMany** access is required.

- Must have "100Gi" capacity.

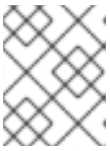
IMPORTANT

Testing shows issues with using the NFS server on RHEL as storage backend for core services. This includes the OpenShift Container Registry and Quay, Prometheus for monitoring storage, and Elasticsearch for logging storage. Therefore, using RHEL NFS to back PVs used by core services is not recommended.

Other NFS implementations on the marketplace might not have these issues. Contact the individual NFS implementation vendor for more information on any testing that was possibly completed against these OpenShift Container Platform core components.

Procedure

1. To configure your registry to use storage, change the **spec.storage.pvc** in the **configs.imageregistry/cluster** resource.



NOTE

When you use shared storage, review your security settings to prevent outside access.

2. Verify that you do not have a registry pod:

```
$ oc get pod -n openshift-image-registry -l docker-registry=default
```

Example output

```
No resourses found in openshift-image-registry namespace
```

NOTE

If you do have a registry pod in your output, you do not need to continue with this procedure.

3. Check the registry configuration:

```
$ oc edit configs.imageregistry.operator.openshift.io
```

Example output

```
storage:
  pvc:
    claim: 1
```

1 Leave the **claim** field blank to allow the automatic creation of an **image-registry-storage** persistent volume claim (PVC). The PVC is generated based on the default storage class. However, be aware that the default storage class might provide ReadWriteOnce (RWO) volumes, such as a RADOS Block Device (RBD), which can cause issues when you replicate to more than one replica.

4. Check the **clusteroperator** status:

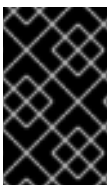
```
$ oc get clusteroperator image-registry
```

Example output

```
NAME             VERSION                             AVAILABLE   PROGRESSING   DEGRADED
SINCE   MESSAGE
image-registry   4.7                                 True        False         False      6h50m
```

21.3.14.2.2. Configuring block registry storage for VMware vSphere

To allow the image registry to use block storage types such as vSphere Virtual Machine Disk (VMDK) during upgrades as a cluster administrator, you can use the **Recreate** rollout strategy.



IMPORTANT

Block storage volumes are supported but not recommended for use with image registry on production clusters. An installation where the registry is configured on block storage is not highly available because the registry cannot have more than one replica.

Procedure

1. Enter the following command to set the image registry storage as a block storage type, patch the registry so that it uses the **Recreate** rollout strategy, and runs with only **1** replica:

```
$ oc patch config.imageregistry.operator.openshift.io/cluster --type=merge -p '{"spec":
{"rolloutStrategy":"Recreate","replicas":1}}'
```

2. Provision the PV for the block storage device, and create a PVC for that volume. The requested block volume uses the ReadWriteOnce (RWO) access mode.

   a. Create a **pvc.yaml** file with the following contents to define a VMware vSphere **PersistentVolumeClaim** object:

```
kind: PersistentVolumeClaim
apiVersion: v1
metadata:
  name: image-registry-storage 1
  namespace: openshift-image-registry 2
spec:
  accessModes:
  - ReadWriteOnce 3
  resources:
    requests:
      storage: 100Gi 4
```

   1. A unique name that represents the **PersistentVolumeClaim** object.
   2. The namespace for the **PersistentVolumeClaim** object, which is **openshift-image-registry**.
   3. The access mode of the persistent volume claim. With **ReadWriteOnce**, the volume can be mounted with read and write permissions by a single node.
   4. The size of the persistent volume claim.

   b. Enter the following command to create the **PersistentVolumeClaim** object from the file:

```
$ oc create -f pvc.yaml -n openshift-image-registry
```

3. Enter the following command to edit the registry configuration so that it references the correct PVC:

```
$ oc edit config.imageregistry.operator.openshift.io -o yaml
```

Example output

```
storage:
  pvc:
    claim: 1
```

1. By creating a custom PVC, you can leave the **claim** field blank for the default automatic creation of an **image-registry-storage** PVC.

For instructions about configuring registry storage so that it references the correct PVC, see Configuring the registry for vSphere.

21.3.15. Backing up VMware vSphere volumes

OpenShift Container Platform provisions new volumes as independent persistent disks to freely attach and detach the volume on any node in the cluster. As a consequence, it is not possible to back up volumes that use snapshots, or to restore volumes from snapshots. See Snapshot Limitations for more information.

Procedure

To create a backup of persistent volumes:

1. Stop the application that is using the persistent volume.
2. Clone the persistent volume.
3. Restart the application.
4. Create a backup of the cloned volume.
5. Delete the cloned volume.

21.3.16. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.11, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to OpenShift Cluster Manager Hybrid Cloud Console.

After you confirm that your OpenShift Cluster Manager Hybrid Cloud Console inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, use subscription watch to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

Additional resources

- See About remote health monitoring for more information about the Telemetry service

21.3.17. Configuring an external load balancer

You can configure an OpenShift Container Platform cluster to use an external load balancer in place of the default load balancer.

IMPORTANT

Configuring an external load balancer depends on your vendor's load balancer.

The information and examples in this section are for guideline purposes only. Consult the vendor documentation for more specific information about the vendor's load balancer.

Red Hat supports the following services for an external load balancer:

- Ingress Controller
- OpenShift API
- OpenShift MachineConfig API

You can choose whether you want to configure one or all of these services for an external load balancer. Configuring only the Ingress Controller service is a common configuration option. To better understand each service, view the following diagrams:

Figure 21.4. Example network workflow that shows an Ingress Controller operating in an OpenShift Container Platform environment

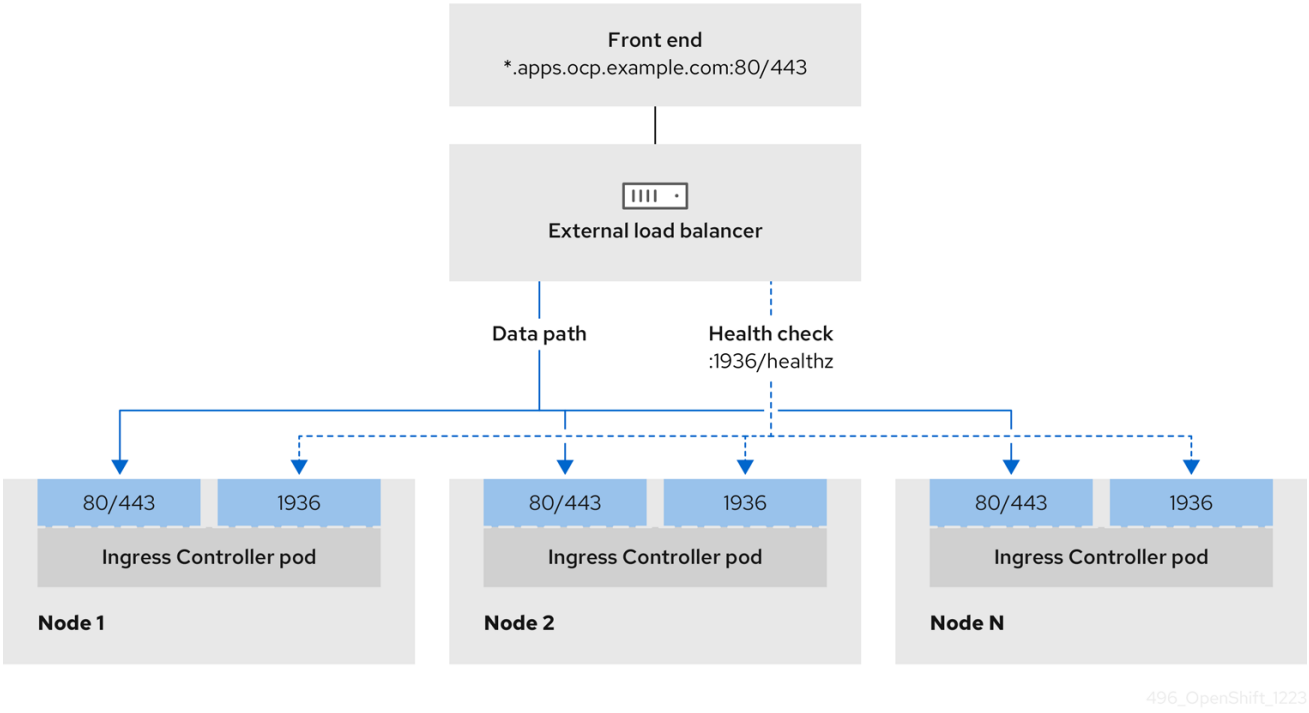


Figure 21.5. Example network workflow that shows an OpenShift API operating in an OpenShift Container Platform environment

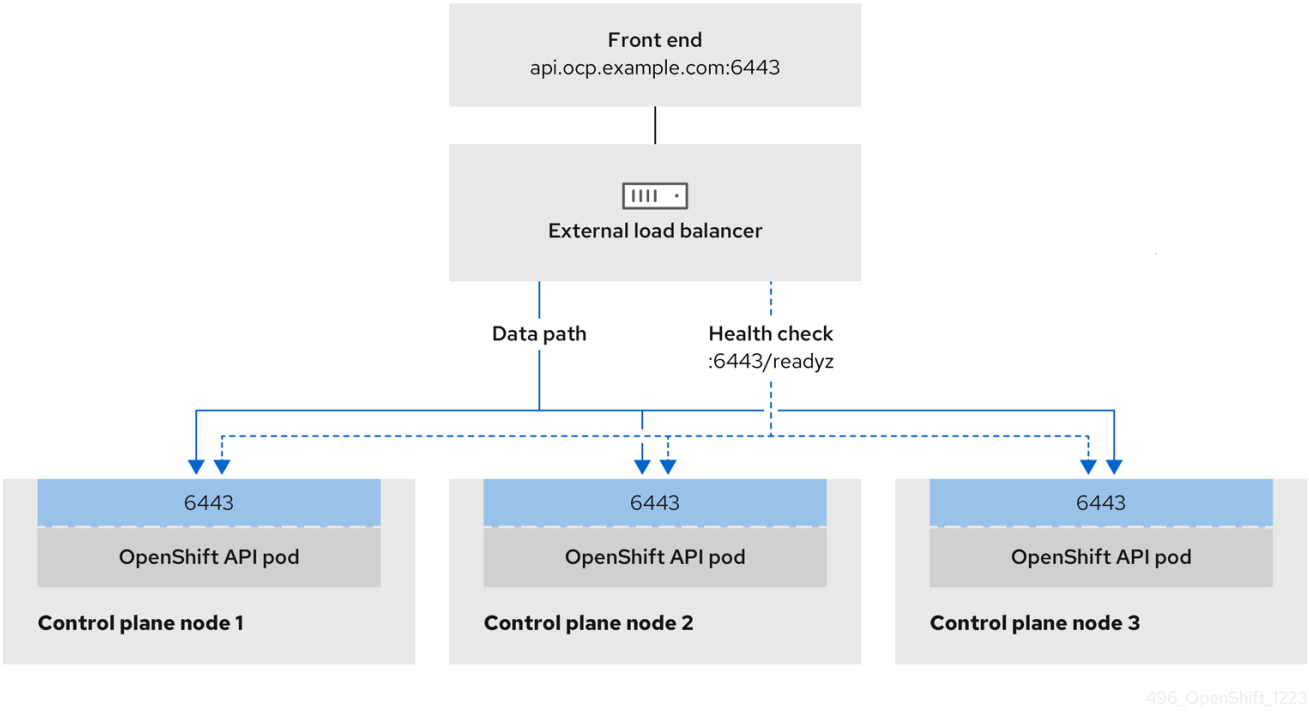
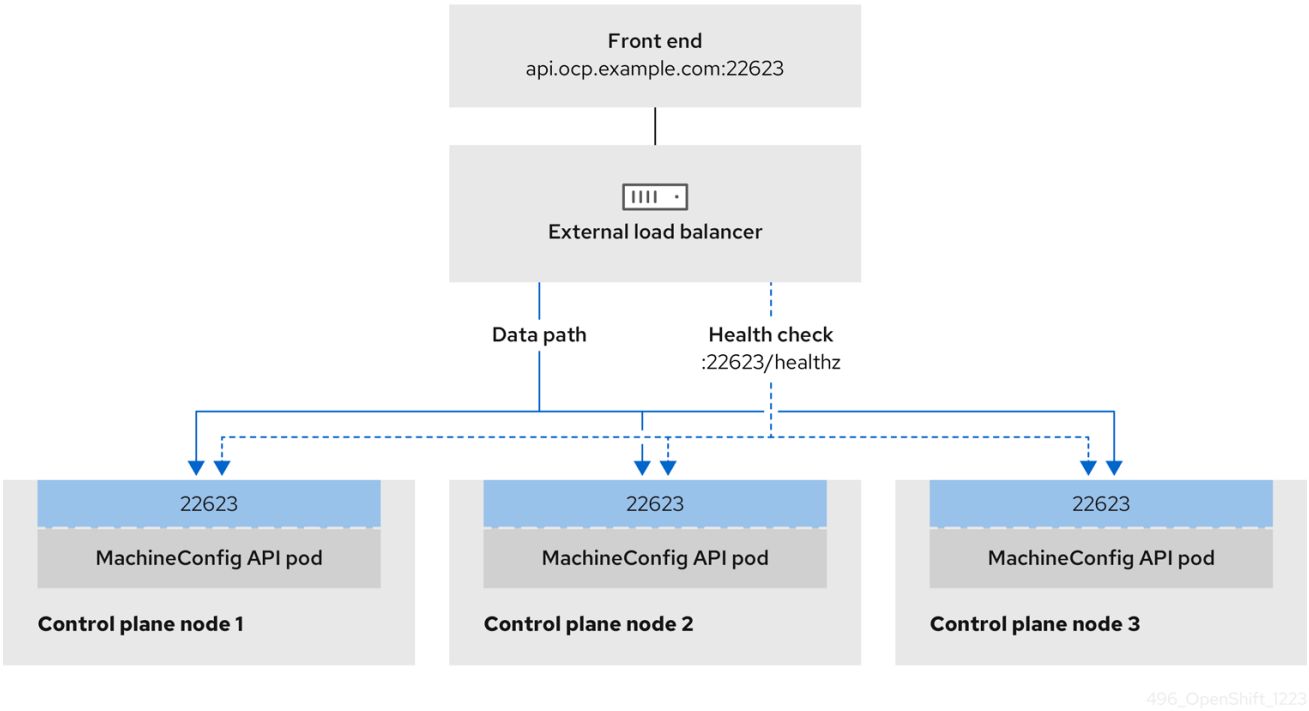


Figure 21.6. Example network workflow that shows an OpenShift MachineConfig API operating in an OpenShift Container Platform environment



Considerations

- For a front-end IP address, you can use the same IP address for the front-end IP address, the Ingress Controller's load balancer, and API load balancer. Check the vendor's documentation for this capability.
- For a back-end IP address, ensure that an IP address for an OpenShift Container Platform control plane node does not change during the lifetime of the external load balancer. You can achieve this by completing one of the following actions:
  - Assign a static IP address to each control plane node.
  - Configure each node to receive the same IP address from the DHCP every time the node requests a DHCP lease. Depending on the vendor, the DHCP lease might be in the form of an IP reservation or a static DHCP assignment.
- Manually define each node that runs the Ingress Controller in the external load balancer for the Ingress Controller back-end service. For example, if the Ingress Controller moves to an undefined node, a connection outage can occur.

OpenShift API prerequisites

- You defined a front-end IP address.
- TCP ports 6443 and 22623 are exposed on the front-end IP address of your load balancer. Check the following items:
  - Port 6443 provides access to the OpenShift API service.
  - Port 22623 can provide ignition startup configurations to nodes.

- The front-end IP address and port 6443 are reachable by all users of your system with a location external to your OpenShift Container Platform cluster.
- The front-end IP address and port 22623 are reachable only by OpenShift Container Platform nodes.
- The load balancer backend can communicate with OpenShift Container Platform control plane nodes on port 6443 and 22623.

Ingress Controller prerequisites

- You defined a front-end IP address.
- TCP ports 443 and 80 are exposed on the front-end IP address of your load balancer.
- The front-end IP address, port 80 and port 443 are be reachable by all users of your system with a location external to your OpenShift Container Platform cluster.
- The front-end IP address, port 80 and port 443 are reachable to all nodes that operate in your OpenShift Container Platform cluster.
- The load balancer backend can communicate with OpenShift Container Platform nodes that run the Ingress Controller on ports 80, 443, and 1936.

Prerequisite for health check URL specifications

You can configure most load balancers by setting health check URLs that determine if a service is available or unavailable. OpenShift Container Platform provides these health checks for the OpenShift API, Machine Configuration API, and Ingress Controller backend services.

The following examples demonstrate health check specifications for the previously listed backend services:

Example of a Kubernetes API health check specification

```
Path: HTTPS:6443/readyz
Healthy threshold: 2
Unhealthy threshold: 2
Timeout: 10
Interval: 10
```

Example of a Machine Config API health check specification

```
Path: HTTPS:22623/healthz
Healthy threshold: 2
Unhealthy threshold: 2
Timeout: 10
Interval: 10
```

Example of an Ingress Controller health check specification

```
Path: HTTP:1936/healthz/ready
Healthy threshold: 2
Unhealthy threshold: 2
```

```
Timeout: 5
Interval: 10
```

Procedure

1. Configure the HAProxy Ingress Controller, so that you can enable access to the cluster from your load balancer on ports 6443, 443, and 80:

   Example HAProxy configuration

```
#...
listen my-cluster-api-6443
    bind 192.168.1.100:6443
    mode tcp
    balance roundrobin
  option httpchk
  http-check connect
  http-check send meth GET uri /readyz
  http-check expect status 200
    server my-cluster-master-2 192.168.1.101:6443 check inter 10s rise 2 fall 2
    server my-cluster-master-0 192.168.1.102:6443 check inter 10s rise 2 fall 2
    server my-cluster-master-1 192.168.1.103:6443 check inter 10s rise 2 fall 2

listen my-cluster-machine-config-api-22623
    bind 192.168.1.1000.0.0.0:22623
    mode tcp
    balance roundrobin
  option httpchk
  http-check connect
  http-check send meth GET uri /healthz
  http-check expect status 200
    server my-cluster-master-2 192.0168.21.2101:22623 check inter 10s rise 2 fall 2
    server my-cluster-master-0 192.168.1.1020.2.3:22623 check inter 10s rise 2 fall 2
    server my-cluster-master-1 192.168.1.1030.2.1:22623 check inter 10s rise 2 fall 2

listen my-cluster-apps-443
        bind 192.168.1.100:443
        mode tcp
        balance roundrobin
    option httpchk
    http-check connect
    http-check send meth GET uri /healthz/ready
    http-check expect status 200
        server my-cluster-worker-0 192.168.1.111:443 check port 1936 inter 10s rise 2 fall 2
        server my-cluster-worker-1 192.168.1.112:443 check port 1936 inter 10s rise 2 fall 2
        server my-cluster-worker-2 192.168.1.113:443 check port 1936 inter 10s rise 2 fall 2

listen my-cluster-apps-80
        bind 192.168.1.100:80
        mode tcp
        balance roundrobin
    option httpchk
    http-check connect
    http-check send meth GET uri /healthz/ready
    http-check expect status 200
```

```
        server my-cluster-worker-0 192.168.1.111:80 check port 1936 inter 10s rise 2 fall 2
        server my-cluster-worker-1 192.168.1.112:80 check port 1936 inter 10s rise 2 fall 2
        server my-cluster-worker-2 192.168.1.113:80 check port 1936 inter 10s rise 2 fall 2
# ...
```

2. Use the **curl** CLI command to verify that the external load balancer and its resources are operational:

   a. Verify that the cluster machine configuration API is accessible to the Kubernetes API server resource, by running the following command and observing the response:

   ```
   $ curl https://<loadbalancer_ip_address>:6443/version --insecure
   ```

   If the configuration is correct, you receive a JSON object in response:

   ```
   {
     "major": "1",
     "minor": "11+",
     "gitVersion": "v1.11.0+ad103ed",
     "gitCommit": "ad103ed",
     "gitTreeState": "clean",
     "buildDate": "2019-01-09T06:44:10Z",
     "goVersion": "go1.10.3",
     "compiler": "gc",
     "platform": "linux/amd64"
   }
   ```

   b. Verify that the cluster machine configuration API is accessible to the Machine config server resource, by running the following command and observing the output:

   ```
   $ curl -v https://<loadbalancer_ip_address>:22623/healthz --insecure
   ```

   If the configuration is correct, the output from the command shows the following response:

   ```
   HTTP/1.1 200 OK
   Content-Length: 0
   ```

   c. Verify that the controller is accessible to the Ingress Controller resource on port 80, by running the following command and observing the output:

   ```
   $ curl -I -L -H "Host: console-openshift-console.apps.<cluster_name>.<base_domain>"
   http://<load_balancer_front_end_IP_address>
   ```

   If the configuration is correct, the output from the command shows the following response:

   ```
   HTTP/1.1 302 Found
   content-length: 0
   location: https://console-openshift-console.apps.ocp4.private.opequon.net/
   cache-control: no-cache
   ```

   d. Verify that the controller is accessible to the Ingress Controller resource on port 443, by running the following command and observing the output:

```
$ curl -I -L --insecure --resolve console-openshift-console.apps.<cluster_name>.
<base_domain>:443:<Load Balancer Front End IP Address> https://console-openshift-
console.apps.<cluster_name>.<base_domain>
```

If the configuration is correct, the output from the command shows the following response:

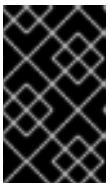
```
HTTP/1.1 200 OK
referrer-policy: strict-origin-when-cross-origin
set-cookie: csrf-
token=UlYWOyQ62LWjw2h003xtYSKlh1a0Py2hhctw0WmV2YEdhJjFyQwWcGBsja261dG
LgaYO0nxzVErhiXt6QepA7g==; Path=/; Secure; SameSite=Lax
x-content-type-options: nosniff
x-dns-prefetch-control: off
x-frame-options: DENY
x-xss-protection: 1; mode=block
date: Wed, 04 Oct 2023 16:29:38 GMT
content-type: text/html; charset=utf-8
set-cookie:
1e2670d92730b515ce3a1bb65da45062=1bf5e9573c9a2760c964ed1659cc1673; path=/;
HttpOnly; Secure; SameSite=None
cache-control: private
```

3. Configure the DNS records for your cluster to target the front-end IP addresses of the external load balancer. You must update records to your DNS server for the cluster API and applications over the load balancer.

Examples of modified DNS records

```
<load_balancer_ip_address>  A  api.<cluster_name>.<base_domain>
A record pointing to Load Balancer Front End
```

```
<load_balancer_ip_address>  A apps.<cluster_name>.<base_domain>
A record pointing to Load Balancer Front End
```



IMPORTANT

DNS propagation might take some time for each DNS record to become available. Ensure that each DNS record propagates before validating each record.

4. Use the **curl** CLI command to verify that the external load balancer and DNS record configuration are operational:

   a. Verify that you can access the cluster API, by running the following command and observing the output:

```
$ curl https://api.<cluster_name>.<base_domain>:6443/version --insecure
```

   If the configuration is correct, you receive a JSON object in response:

```
{
  "major": "1",
  "minor": "11+",
```

```
  "gitVersion": "v1.11.0+ad103ed",
  "gitCommit": "ad103ed",
  "gitTreeState": "clean",
  "buildDate": "2019-01-09T06:44:10Z",
  "goVersion": "go1.10.3",
  "compiler": "gc",
  "platform": "linux/amd64"
  }
```

b. Verify that you can access the cluster machine configuration, by running the following command and observing the output:

```
$ curl -v https://api.<cluster_name>.<base_domain>:22623/healthz --insecure
```

If the configuration is correct, the output from the command shows the following response:

```
HTTP/1.1 200 OK
Content-Length: 0
```

c. Verify that you can access each cluster application on port, by running the following command and observing the output:

```
$ curl http://console-openshift-console.apps.<cluster_name>.<base_domain> -I -L --
insecure
```

If the configuration is correct, the output from the command shows the following response:

```
HTTP/1.1 302 Found
content-length: 0
location: https://console-openshift-console.apps.<cluster-name>.<base domain>/
cache-control: no-cacheHTTP/1.1 200 OK
referrer-policy: strict-origin-when-cross-origin
set-cookie: csrf-
token=39HoZgztDnzjJkq/JuLJMeoKNXlfiVv2YgZc09c3TBOBU4Nl6kDXaJH1LdicNhN1UsQ
Wzon4Dor9GWGfopaTEQ==; Path=/; Secure
x-content-type-options: nosniff
x-dns-prefetch-control: off
x-frame-options: DENY
x-xss-protection: 1; mode=block
date: Tue, 17 Nov 2020 08:42:10 GMT
content-type: text/html; charset=utf-8
set-cookie:
1e2670d92730b515ce3a1bb65da45062=9b714eb87e93cf34853e87a92d6894be; path=/;
HttpOnly; Secure; SameSite=None
cache-control: private
```

d. Verify that you can access each cluster application on port 443, by running the following command and observing the output:

```
$ curl https://console-openshift-console.apps.<cluster_name>.<base_domain> -I -L --
insecure
```

If the configuration is correct, the output from the command shows the following response:

```
HTTP/1.1 200 OK
referrer-policy: strict-origin-when-cross-origin
set-cookie: csrf-
token=UlYWOyQ62LWjw2h003xtYSKlh1a0Py2hhctw0WmV2YEdhJjFyQwWcGBsja261dG
LgaYO0nxzVErhiXt6QepA7g==; Path=/; Secure; SameSite=Lax
x-content-type-options: nosniff
x-dns-prefetch-control: off
x-frame-options: DENY
x-xss-protection: 1; mode=block
date: Wed, 04 Oct 2023 16:29:38 GMT
content-type: text/html; charset=utf-8
set-cookie:
1e2670d92730b515ce3a1bb65da45062=1bf5e9573c9a2760c964ed1659cc1673; path=/;
HttpOnly; Secure; SameSite=None
cache-control: private
```

21.3.18. Next steps

- Customize your cluster.
- If necessary, you can opt out of remote health reporting .
- Set up your registry and configure registry storage .
- Optional: View the events from the vSphere Problem Detector Operator to determine if the cluster has permission or storage configuration issues.

21.4. INSTALLING A CLUSTER ON VSPHERE WITH NETWORK CUSTOMIZATIONS

In OpenShift Container Platform version 4.11, you can install a cluster on your VMware vSphere instance by using installer-provisioned infrastructure with customized network configuration options. By customizing your network configuration, your cluster can coexist with existing IP address allocations in your environment and integrate with existing MTU and VXLAN configurations. To customize the installation, you modify parameters in the **install-config.yaml** file before you install the cluster.

You must set most of the network configuration parameters during installation, and you can modify only **kubeProxy** configuration parameters in a running cluster.

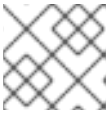
NOTE

OpenShift Container Platform supports deploying a cluster to a single VMware vCenter only. Deploying a cluster with machines/machine sets on multiple vCenters is not supported.

21.4.1. Prerequisites

- You reviewed details about the OpenShift Container Platform installation and update processes.
- You read the documentation on selecting a cluster installation method and preparing it for users.

- You provisioned persistent storage for your cluster. To deploy a private image registry, your storage must provide **ReadWriteMany** access modes.
- The OpenShift Container Platform installer requires access to port 443 on the vCenter and ESXi hosts. You verified that port 443 is accessible.
- If you use a firewall, confirm with the administrator that port 443 is accessible. Control plane nodes must be able to reach vCenter and ESXi hosts on port 443 for the installation to succeed.
- If you use a firewall, you configured it to allow the sites that your cluster requires access to.



NOTE

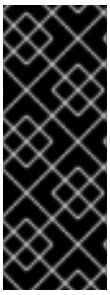
Be sure to also review this site list if you are configuring a proxy.

21.4.2. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.11, you require access to the internet to install your cluster.

You must have internet access to:

- Access OpenShift Cluster Manager Hybrid Cloud Console to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access Quay.io to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.



IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

21.4.3. VMware vSphere infrastructure requirements

You must install the OpenShift Container Platform cluster on a VMware vSphere version 7 instance that meets the requirements for the components that you use.

NOTE

OpenShift Container Platform version 4.11 does not support VMware vSphere version 8.0.

You can host the VMware vSphere infrastructure on-premise or on a VMware Cloud Verified provider that meets the requirements outlined in the following table:

Table 21.20. Version requirements for vSphere virtual environments

Virtual environment product	Required version
VM hardware version	15 or later
vSphere ESXi hosts	7
vCenter host	7

IMPORTANT

Installing a cluster on VMware vSphere version 7.0 Update 1 or earlier is now deprecated. These versions are still fully supported, but version 4.11 of OpenShift Container Platform requires vSphere virtual hardware version 15 or later. Hardware version 15 is now the default for vSphere virtual machines in OpenShift Container Platform. To update the hardware version for your vSphere nodes, see the "Updating hardware on nodes running in vSphere" article.

If your vSphere nodes are below hardware version 15 or your VMware vSphere version is earlier than 6.7.3, upgrading from OpenShift Container Platform 4.10 to OpenShift Container Platform 4.11 is not available.

Table 21.21. Minimum supported vSphere version for VMware components

Component	Minimum supported versions	Description
Hypervisor	vSphere 7 with HW version 15	This version is the minimum version that Red Hat Enterprise Linux CoreOS (RHCOS) supports. For more information about supported hardware on the latest version of Red Hat Enterprise Linux (RHEL) that is compatible with RHCOS, see Hardware on the Red Hat Customer Portal.
Storage with in-tree drivers	vSphere 7	This plugin creates vSphere storage by using the in-tree storage drivers for vSphere included in OpenShift Container Platform.
Optional: Networking (NSX-T)	vSphere 7	vSphere 7 is required for OpenShift Container Platform. For more information about the compatibility of NSX and OpenShift Container Platform, see the Release Notes section of VMware's NSX container plugin documentation.

IMPORTANT

You must ensure that the time on your ESXi hosts is synchronized before you install OpenShift Container Platform. See Edit Time Configuration for a Host in the VMware documentation.

21.4.4. Network connectivity requirements

You must configure the network connectivity between machines to allow OpenShift Container Platform cluster components to communicate.

Review the following details about the required network ports.

Table 21.22. Ports used for all-machine to all-machine communications

Protocol	Port	Description
ICMP	N/A	Network reachability tests
TCP	**1936**	Metrics
	9000-**9999**	Host level services, including the node exporter on ports **9100**-**9101** and the Cluster Version Operator on port**9099**.
	10250-**10259**	The default ports that Kubernetes reserves
	10256	openshift-sdn
UDP	**4789**	virtual extensible LAN (VXLAN)
	6081	Geneve
	9000-**9999**	Host level services, including the node exporter on ports **9100**-**9101**.
	500	IPsec IKE packets
	4500	IPsec NAT-T packets
TCP/UDP	**30000**-**32767**	Kubernetes node port
ESP	N/A	IPsec Encapsulating Security Payload (ESP)

Table 21.23. Ports used for all-machine to control plane communications

Protocol	Port	Description
TCP	**6443**	Kubernetes API

Table 21.24. Ports used for control plane machine to control plane machine communications

Protocol	Port	Description
TCP	**2379-2380**	etcd server and peer ports

21.4.5. VMware vSphere CSI Driver Operator requirements

To install the vSphere CSI Driver Operator, the following requirements must be met:

- VMware vSphere version 7.0 Update 1 or later
- Virtual machines of hardware version 15 or later
- No third-party vSphere CSI driver already installed in the cluster

IMPORTANT

If a third-party vSphere CSI driver is present in the cluster, OpenShift Container Platform does not overwrite it. If you continue with the third-party vSphere CSI driver when upgrading to the next major version of OpenShift Container Platform, the **oc** CLI prompts you with the following message:

> VSphereCSIDriverOperatorCRUpgradeable: VMwareVSphereControllerUpgradeable: found existing unsupported csi.vsphere.vmware.com driver

The previous message informs you that Red Hat does not support the third-party vSphere CSI driver during an OpenShift Container Platform upgrade operation. You can choose to ignore this message and continue with the upgrade operation.

Additional resources

- To remove a third-party vSphere CSI driver, see Removing a third-party vSphere CSI Driver .
- To update the hardware version for your vSphere nodes, see Updating hardware on nodes running in vSphere.

21.4.6. vCenter requirements

Before you install an OpenShift Container Platform cluster on your vCenter that uses infrastructure that the installer provisions, you must prepare your environment.

Required vCenter account privileges
To install an OpenShift Container Platform cluster in a vCenter, the installation program requires access to an account with privileges to read and create the required resources. Using an account that has global administrative privileges is the simplest way to access all of the necessary permissions.

If you cannot use an account with global administrative privileges, you must create roles to grant the privileges necessary for OpenShift Container Platform cluster installation. While most of the privileges are always required, some are required only if you plan for the installation program to provision a folder to contain the OpenShift Container Platform cluster on your vCenter instance, which is the default behavior. You must create or amend vSphere roles for the specified objects to grant the required privileges.

An additional role is required if the installation program is to create a vSphere virtual machine folder.

Example 21.7. Roles and privileges required for installation in vSphere API

vSphere object for role	When required	Required privileges in vSphere API
vSphere vCenter	Always	**Cns.Searchable** **InventoryService.Tagging.AttachTag** **InventoryService.Tagging.CreateCategory** **InventoryService.Tagging.CreateTag** **InventoryService.Tagging.DeleteCategory** **InventoryService.Tagging.DeleteTag** **InventoryService.Tagging.EditCategory** **InventoryService.Tagging.EditTag** **Sessions.ValidateSession** **StorageProfile.Update** **StorageProfile.View**
vSphere vCenter Cluster	If VMs will be created in the cluster root	**Host.Config.Storage** **Resource.AssignVMToPool** **VApp.AssignResourcePool** **VApp.Import** **VirtualMachine.Config.AddNewDisk**
vSphere vCenter Resource Pool	If an existing resource pool is provided	**Host.Config.Storage** **Resource.AssignVMToPool** **VApp.AssignResourcePool** **VApp.Import** **VirtualMachine.Config.AddNewDisk**
vSphere Datastore	Always	**Datastore.AllocateSpace** **Datastore.Browse** **Datastore.FileManagement** **InventoryService.Tagging.ObjectAttachable**
vSphere Port Group	Always	**Network.Assign**
Virtual Machine Folder	Always	**InventoryService.Tagging.ObjectAttachable** **Resource.AssignVMToPool** **VApp.Import** **VirtualMachine.Config.Add**

vSphere object for role	When required	Required privileges in vSphere API
		ExistingDisk **VirtualMachine.Config.AddNewDisk** **VirtualMachine.Config.AddRemoveDevice** **VirtualMachine.Config.AdvancedConfig** **VirtualMachine.Config.Annotation** **VirtualMachine.Config.CPUCount** **VirtualMachine.Config.DiskExtend** **VirtualMachine.Config.DiskLease** **VirtualMachine.Config.EditDevice** **VirtualMachine.Config.Memory** **VirtualMachine.Config.RemoveDisk** **VirtualMachine.Config.Rename** **VirtualMachine.Config.ResetGuestInfo** **VirtualMachine.Config.Resource** **VirtualMachine.Config.Settings** **VirtualMachine.Config.UpgradeVirtualHardware** **VirtualMachine.Interact.GuestControl** **VirtualMachine.Interact.PowerOff** **VirtualMachine.Interact.PowerOn** **VirtualMachine.Interact.Reset** **VirtualMachine.Inventory.Create** **VirtualMachine.Inventory.CreateFromExisting** **VirtualMachine.Inventory.Delete** **VirtualMachine.Provisioning.Clone** **VirtualMachine.Provisioning.MarkAsTemplate** **VirtualMachine.Provisioning.DeployTemplate**
vSphere vCenter Datacenter	If the installation program creates the virtual machine folder	**InventoryService.Tagging.ObjectAttachable** **Resource.AssignVMToPool** **VApp.Import**

vSphere object for role	When required	Required privileges in vSphere API
		VirtualMachine.Config.AddExistingDisk VirtualMachine.Config.AddNewDisk VirtualMachine.Config.AddRemoveDevice VirtualMachine.Config.AdvancedConfig VirtualMachine.Config.Annotation VirtualMachine.Config.CPUCount VirtualMachine.Config.DiskExtend VirtualMachine.Config.DiskLease VirtualMachine.Config.EditDevice VirtualMachine.Config.Memory VirtualMachine.Config.RemoveDisk VirtualMachine.Config.Rename VirtualMachine.Config.ResetGuestInfo VirtualMachine.Config.Resource VirtualMachine.Config.Settings VirtualMachine.Config.UpgradeVirtualHardware VirtualMachine.Interact.GuestControl VirtualMachine.Interact.PowerOff VirtualMachine.Interact.PowerOn VirtualMachine.Interact.Reset VirtualMachine.Inventory.Create VirtualMachine.Inventory.CreateFromExisting VirtualMachine.Inventory.Delete VirtualMachine.Provisioning.Clone VirtualMachine.Provisioning.DeployTemplate VirtualMachine.Provisioning.MarkAsTemplate Folder.Create Folder.Delete

Example 21.8. Roles and privileges required for installation in vCenter graphical user interface (GUI)

vSphere object for role	When required	Required privileges in vCenter GUI
vSphere vCenter	Always	**Cns.Searchable "vSphere Tagging"."Assign or Unassign vSphere Tag" "vSphere Tagging"."Create vSphere Tag Category" "vSphere Tagging"."Create vSphere Tag" vSphere Tagging"."Delete vSphere Tag Category" "vSphere Tagging"."Delete vSphere Tag" "vSphere Tagging"."Edit vSphere Tag Category" "vSphere Tagging"."Edit vSphere Tag" Sessions."Validate session" "Profile-driven storage"."Profile-driven storage update" "Profile-driven storage"."Profile-driven storage view"**
vSphere vCenter Cluster	If VMs will be created in the cluster root	**Host.Configuration."Storage partition configuration" Resource."Assign virtual machine to resource pool" VApp."Assign resource pool" VApp.Import "Virtual machine"."Change Configuration"."Add new disk"**
vSphere vCenter Resource Pool	If an existing resource pool is provided	**Host.Configuration."Storage partition configuration" Resource."Assign virtual machine to resource pool" VApp."Assign resource pool" VApp.Import "Virtual machine"."Change Configuration"."Add new disk"**

vSphere object for role	When required	Required privileges in vCenter GUI
vSphere Datastore	Always	**Datastore."Allocate space" Datastore."Browse datastore" Datastore."Low level file operations" "vSphere Tagging"."Assign or Unassign vSphere Tag on Object"**
vSphere Port Group	Always	**Network."Assign network"**
Virtual Machine Folder	Always	**"vSphere Tagging"."Assign or Unassign vSphere Tag on Object" Resource."Assign virtual machine to resource pool" VApp.Import "Virtual machine"."Change Configuration"."Add existing disk" "Virtual machine"."Change Configuration"."Add new disk" "Virtual machine"."Change Configuration"."Add or remove device" "Virtual machine"."Change Configuration"."Advanced configuration" "Virtual machine"."Change Configuration"."Set annotation" "Virtual machine"."Change Configuration"."Change CPU count" "Virtual machine"."Change Configuration"."Extend virtual disk" "Virtual machine"."Change Configuration"."Acquire disk lease" "Virtual machine"."Change Configuration"."Modify device settings" "Virtual machine"."Change Configuration"."Change Memory" "Virtual machine"."Change Configuration"."Remove**

vSphere object for role	When required	Required privileges in vCenter GUI
		disk" "Virtual machine"."Change Configuration".Rename "Virtual machine"."Change Configuration"."Reset guest information" "Virtual machine"."Change Configuration"."Change resource" "Virtual machine"."Change Configuration"."Change Settings" "Virtual machine"."Change Configuration"."Upgrade virtual machine compatibility" "Virtual machine".Interaction."Guest operating system management by VIX API" "Virtual machine".Interaction."Power off" "Virtual machine".Interaction."Power on" "Virtual machine".Interaction.Reset "Virtual machine"."Edit Inventory"."Create new" "Virtual machine"."Edit Inventory"."Create from existing" "Virtual machine"."Edit Inventory"."Remove" "Virtual machine".Provisioning."Clone virtual machine" "Virtual machine".Provisioning."Mark as template" "Virtual machine".Provisioning."Deploy template"
vSphere vCenter Datacenter	If the installation program creates the virtual machine folder	**"vSphere Tagging"."Assign or Unassign vSphere Tag on Object" Resource."Assign virtual machine to resource pool" VApp.Import "Virtual machine"."Change Configuration"."Add existing disk" "Virtual machine"."Change Configuration"."Add new**

vSphere object for role	When required	Required privileges in vCenter GUI
		disk" "Virtual machine"."Change Configuration"."Add or remove device" "Virtual machine"."Change Configuration"."Advanced configuration" "Virtual machine"."Change Configuration"."Set annotation" "Virtual machine"."Change Configuration"."Change CPU count" "Virtual machine"."Change Configuration"."Extend virtual disk" "Virtual machine"."Change Configuration"."Acquire disk lease" "Virtual machine"."Change Configuration"."Modify device settings" "Virtual machine"."Change Configuration"."Change Memory" "Virtual machine"."Change Configuration"."Remove disk" "Virtual machine"."Change Configuration".Rename "Virtual machine"."Change Configuration"."Reset guest information" "Virtual machine"."Change Configuration"."Change resource" "Virtual machine"."Change Configuration"."Change Settings" "Virtual machine"."Change Configuration"."Upgrade virtual machine compatibility" "Virtual machine".Interaction."Guest operating system management by VIX API" "Virtual machine".Interaction."Power off" "Virtual machine".Interaction."Power on" "Virtual machine".Interaction.Reset "Virtual machine"."Edit

vSphere object for role	When required	Required privileges in vCenter GUI
		Inventory"."Create new" "Virtual machine"."Edit Inventory"."Create from existing" "Virtual machine"."Edit Inventory"."Remove" "Virtual machine".Provisioning."Clone virtual machine" "Virtual machine".Provisioning."Deploy template" "Virtual machine".Provisioning."Mark as template" Folder."Create folder" Folder."Delete folder"

Additionally, the user requires some **ReadOnly** permissions, and some of the roles require permission to propogate the permissions to child objects. These settings vary depending on whether or not you install the cluster into an existing folder.

Example 21.9. Required permissions and propagation settings

vSphere object	When required	Propagate to children	Permissions required
vSphere vCenter	Always	False	Listed required privileges
vSphere vCenter Datacenter	Existing folder	False	**ReadOnly** permission
	Installation program creates the folder	True	Listed required privileges
vSphere vCenter Cluster	Existing resource pool	False	**ReadOnly** permission
	VMs in cluster root	True	Listed required privileges
vSphere vCenter Datastore	Always	False	Listed required privileges
vSphere Switch	Always	False	**ReadOnly** permission
vSphere Port Group	Always	False	Listed required privileges
vSphere vCenter Virtual Machine Folder	Existing folder	True	Listed required privileges

vSphere object	When required	Propagate to children	Permissions required
vSphere vCenter Resource Pool	Existing resource pool	True	Listed required privileges

For more information about creating an account with only the required privileges, see vSphere Permissions and User Management Tasks in the vSphere documentation.

Using OpenShift Container Platform with vMotion
If you intend on using vMotion in your vSphere environment, consider the following before installing a OpenShift Container Platform cluster.

- OpenShift Container Platform generally supports compute-only vMotion, where *generally* implies that you meet all VMware best practices for vMotion.
  To help ensure the uptime of your compute and control plane nodes, ensure that you follow the VMware best practices for vMotion, and use VMware anti-affinity rules to improve the availability of OpenShift Container Platform during maintenance or hardware issues.

  For more information about vMotion and anti-affinity rules, see the VMware vSphere documentation for vMotion networking requirements and VM anti-affinity rules.

- Using Storage vMotion can cause issues and is not supported. If you are using vSphere volumes in your pods, migrating a VM across datastores, either manually or through Storage vMotion, causes invalid references within OpenShift Container Platform persistent volume (PV) objects that can result in data loss.

- OpenShift Container Platform does not support selective migration of VMDKs across datastores, using datastore clusters for VM provisioning or for dynamic or static provisioning of PVs, or using a datastore that is part of a datastore cluster for dynamic or static provisioning of PVs.

Cluster resources
When you deploy an OpenShift Container Platform cluster that uses installer-provisioned infrastructure, the installation program must be able to create several resources in your vCenter instance.

A standard OpenShift Container Platform installation creates the following vCenter resources:

- 1 Folder
- 1 Tag category
- 1 Tag
- Virtual machines:
  - 1 template
  - 1 temporary bootstrap node
  - 3 control plane nodes
  - 3 compute machines

Although these resources use 856 GB of storage, the bootstrap node is destroyed during the cluster installation process. A minimum of 800 GB of storage is required to use a standard cluster.

If you deploy more compute machines, the OpenShift Container Platform cluster will use more storage.

Cluster limits
Available resources vary between clusters. The number of possible clusters within a vCenter is limited primarily by available storage space and any limitations on the number of required resources. Be sure to consider both limitations to the vCenter resources that the cluster creates and the resources that you require to deploy a cluster, such as IP addresses and networks.

Networking requirements
You must use the Dynamic Host Configuration Protocol (DHCP) for the network and ensure that the DHCP server is configured to provide persistent IP addresses to the cluster machines. In the DHCP lease, you must configure the DHCP to use the default gateway. All nodes must be in the same VLAN. You cannot scale the cluster using a second VLAN as a Day 2 operation. Additionally, you must create the following networking resources before you install the OpenShift Container Platform cluster:

NOTE

It is recommended that each OpenShift Container Platform node in the cluster must have access to a Network Time Protocol (NTP) server that is discoverable via DHCP. Installation is possible without an NTP server. However, asynchronous server clocks will cause errors, which NTP server prevents.

Required IP Addresses
An installer-provisioned vSphere installation requires two static IP addresses:

- The **API** address is used to access the cluster API.
- The **Ingress** address is used for cluster ingress traffic.

You must provide these IP addresses to the installation program when you install the OpenShift Container Platform cluster.

DNS records
You must create DNS records for two static IP addresses in the appropriate DNS server for the vCenter instance that hosts your OpenShift Container Platform cluster. In each record, **<cluster_name>** is the cluster name and **<base_domain>** is the cluster base domain that you specify when you install the cluster. A complete DNS record takes the form: **<component>.<cluster_name>.<base_domain>.**.

Table 21.25. Required DNS records

Component	Record	Description
API VIP	**api.<cluster_name>.<base_domain>.**	This DNS A/AAAA or CNAME record must point to the load balancer for the control plane machines. This record must be resolvable by both clients external to the cluster and from all the nodes within the cluster.

Component	Record	Description
Ingress VIP	***.apps.<cluster_name>.<base_domain>.**	A wildcard DNS A/AAAA or CNAME record that points to the load balancer that targets the machines that run the Ingress router pods, which are the worker nodes by default. This record must be resolvable by both clients external to the cluster and from all the nodes within the cluster.

21.4.7. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the **~/.ssh/authorized_keys** list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The **./openshift-install gather** command also requires the SSH public key to be in place on the cluster nodes.

IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.

NOTE

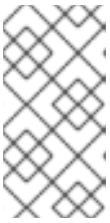
You must use a local key, not one that you configured with platform-specific approaches such as AWS key pairs.

Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N '' -f <path>/<file_name> 1
```

1. Specify the path and file name, such as **~/.ssh/id_ed25519**, of the new SSH key. If you have an existing key pair, ensure your public key is in the your **~/.ssh** directory.



NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS validated or Modules In Process cryptographic libraries on the **x86_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the ~/**.ssh/id_ed25519.pub** public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the **./openshift-install gather** command.

NOTE

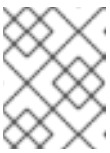
On some distributions, default SSH private key identities such as ~/**.ssh/id_rsa** and ~/**.ssh/id_dsa** are managed automatically.

a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

Example output

```
Agent pid 31874
```



NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

1 Specify the path and file name for your SSH private key, such as ~/**.ssh/id_ed25519**

Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

Next steps

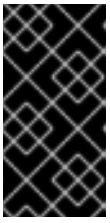
- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

21.4.8. Obtaining the installation program

Before you install OpenShift Container Platform, download the installation file on a local computer.

Prerequisites

- You have a machine that runs Linux, for example Red Hat Enterprise Linux 8, with 500 MB of local disk space.

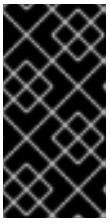


IMPORTANT

If you attempt to run the installation program on macOS, a known issue related to the **golang** compiler causes the installation of the OpenShift Container Platform cluster to fail. For more information about this issue, see the section named "Known Issues" in the *OpenShift Container Platform 4.11 release notes* document.

Procedure

1. Access the Infrastructure Provider page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program that corresponds with your host operating system and architecture, and place the file in the directory where you will store the installation configuration files.



IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.

IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation pull secret from the Red Hat OpenShift Cluster Manager . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

21.4.9. Adding vCenter root CA certificates to your system trust

Because the installation program requires access to your vCenter's API, you must add your vCenter's trusted root CA certificates to your system trust before you install an OpenShift Container Platform cluster.

Procedure

1. From the vCenter home page, download the vCenter's root CA certificates. Click **Download trusted root CA certificates** in the vSphere Web Services SDK section. The **<vCenter>/certs/download.zip** file downloads.

2. Extract the compressed file that contains the vCenter root CA certificates. The contents of the compressed file resemble the following file structure:

```
certs
├── lin
│   ├── 108f4d17.0
│   ├── 108f4d17.r1
│   ├── 7e757f6a.0
│   ├── 8e4f8471.0
│   └── 8e4f8471.r0
├── mac
│   ├── 108f4d17.0
│   ├── 108f4d17.r1
│   ├── 7e757f6a.0
│   ├── 8e4f8471.0
│   └── 8e4f8471.r0
└── win
    ├── 108f4d17.0.crt
    ├── 108f4d17.r1.crl
    ├── 7e757f6a.0.crt
    ├── 8e4f8471.0.crt
    └── 8e4f8471.r0.crl

3 directories, 15 files
```

3. Add the files for your operating system to the system trust. For example, on a Fedora operating system, run the following command:

```
# cp certs/lin/* /etc/pki/ca-trust/source/anchors
```

4. Update your system trust. For example, on a Fedora operating system, run the following command:

```
# update-ca-trust extract
```

21.4.10. Creating the installation configuration file

You can customize the OpenShift Container Platform cluster you install on VMware vSphere.

Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.
- Obtain service principal permissions at the subscription level.

Procedure

1. Create the **install-config.yaml** file.
   a. Change to the directory that contains the installation program and run the following command:

```
$ ./openshift-install create install-config --dir <installation_directory> 1
```

   1 For **<installation_directory>**, specify the directory name to store the files that the installation program creates.

   When specifying the directory:

   - Verify that the directory has the **execute** permission. This permission is required to run Terraform binaries under the installation directory.
   - Use an empty directory. Some installation assets, such as bootstrap X.509 certificates, have short expiration intervals, therefore you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

   b. At the prompts, provide the configuration details for your cloud:
      i. Optional: Select an SSH key to use to access your cluster machines.

NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

      ii. Select **vsphere** as the platform to target.
      iii. Specify the name of your vCenter instance.
      iv. Specify the user name and password for the vCenter account that has the required permissions to create the cluster.
      The installation program connects to your vCenter instance.
      v. Select the datacenter in your vCenter instance to connect to.
      vi. Select the default vCenter datastore to use.
      vii. Select the vCenter cluster to install the OpenShift Container Platform cluster in. The installation program uses the root resource pool of the vSphere cluster as the default resource pool.

viii. Select the network in the vCenter instance that contains the virtual IP addresses and DNS records that you configured.

ix. Enter the virtual IP address that you configured for control plane API access.

x. Enter the virtual IP address that you configured for cluster ingress.

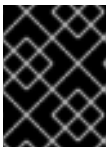
xi. Enter the base domain. This base domain must be the same one that you used in the DNS records that you configured.

xii. Enter a descriptive name for your cluster. The cluster name you enter must match the cluster name you specified when configuring the DNS records.

xiii. Paste the pull secret from the Red Hat OpenShift Cluster Manager .

2. Modify the **install-config.yaml** file. You can find more information about the available parameters in the "Installation configuration parameters" section.

3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.



IMPORTANT

The **install-config.yaml** file is consumed during the installation process. If you want to reuse the file, you must back it up now.

21.4.10.1. Installation configuration parameters

Before you deploy an OpenShift Container Platform cluster, you provide parameter values to describe your account on the cloud platform that hosts your cluster and optionally customize your cluster's platform. When you create the **install-config.yaml** installation configuration file, you provide values for the required parameters through the command line. If you customize your cluster, you can modify the **install-config.yaml** file to provide more details about the platform.

NOTE

After installation, you cannot modify these parameters in the **install-config.yaml** file.

21.4.10.1.1. Required configuration parameters

Required installation configuration parameters are described in the following table:

Table 21.26. Required parameters

Parameter	Description	Values
apiVersion	The API version for the **install-config.yaml** content. The current version is **v1**. The installer may also support older API versions.	String

Parameter	Description	Values
baseDomain	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the **baseDomain** and **metadata.name** parameter values that uses the **<metadata.name>.<baseDomain>** format.	A fully-qualified domain or subdomain name, such as **example.com**.
metadata	Kubernetes resource **ObjectMeta**, from which only the **name** parameter is consumed.	Object
metadata.name	The name of the cluster. DNS records for the cluster are all subdomains of **{{.metadata.name}}.{{.baseDomain}}**.	String of lowercase letters and hyphens (**-**), such as **dev**.
platform	The configuration for the specific platform upon which to perform the installation: **alibabacloud**, **aws**, **baremetal**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**. For additional information about **platform.<platform>** parameters, consult the table for your specific platform that follows.	Object
pullSecret	Get a pull secret from the Red Hat OpenShift Cluster Manager to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	{ "auths":{ "cloud.openshift.com":{ "auth":"b3Blb=", "email":"you@example.com" }, "quay.io":{ "auth":"b3Blb=", "email":"you@example.com" } } }

21.4.10.1.2. Network configuration parameters

You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

Only IPv4 addresses are supported.

NOTE

Globalnet is not supported with Red Hat OpenShift Data Foundation disaster recovery solutions. For regional disaster recovery scenarios, ensure that you use a nonoverlapping range of private IP addresses for the cluster and service networks in each cluster.

Table 21.27. Network parameters

Parameter	Description	Values
networking	The configuration for the cluster network.	Object  NOTE You cannot modify parameters specified by the **networking** object after installation.
networking.networkType	The cluster network provider Container Network Interface (CNI) cluster network provider to install.	Either **OpenShiftSDN** or **OVNKubernetes**. **OpenShiftSDN** is a CNI provider for all-Linux networks. **OVNKubernetes** is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is **OpenShiftSDN**.
networking.clusterNetwork	The IP address blocks for pods. The default value is **10.128.0.0/14** with a host prefix of **/23**. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: `networking:` `  clusterNetwork:` `  - cidr: 10.128.0.0/14` `  hostPrefix: 23`
networking.clusterNetwork.cidr	Required if you use **networking.clusterNetwork**. An IP address block. An IPv4 network.	An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between **0** and **32**.

Parameter	Description	Values
networking.clusterNetwork.hostPrefix	The subnet prefix length to assign to each individual node. For example, if **hostPrefix** is set to **23** then each node is assigned a /**23** subnet out of the given **cidr**. A **hostPrefix** value of **23** provides 510 (2^(32 - 23) - 2) pod IP addresses.	A subnet prefix. The default value is **23**.
networking.serviceNetwork	The IP address block for services. The default value is **172.30.0.0/16**. The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.	An array with an IP address block in CIDR format. For example: networking: serviceNetwork: - 172.30.0.0/16
networking.machineNetwork	The IP address blocks for machines. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: networking: machineNetwork: - cidr: 10.0.0.0/16
networking.machineNetwork.cidr	Required if you use **networking.machineNetwork**. An IP address block. The default value is **10.0.0.0/16** for all platforms other than libvirt. For libvirt, the default value is **192.168.126.0/24**.	An IP network block in CIDR notation. For example, **10.0.0.0/16**. **NOTE** Set the **networking.machineNetwork** to match the CIDR that the preferred NIC resides in.

21.4.10.1.3. Optional configuration parameters

Optional installation configuration parameters are described in the following table:

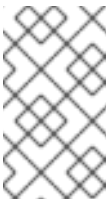
Table 21.28. Optional parameters

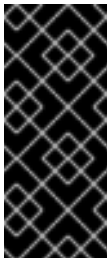
Parameter	Description	Values
additionalTrustBundle	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String

Parameter	Description	Values
capabilities	Controls the installation of optional core cluster components. You can reduce the footprint of your OpenShift Container Platform cluster by disabling optional components.	String array
capabilities.baselineCapabilitySet	Selects an initial set of optional capabilities to enable. Valid values are **None**, **v4.11** and **vCurrent**. **v4.11** enables the **baremetal** Operator, the **marketplace** Operator, and the **openshift-samples** content. **vCurrent** installs the recommended set of capabilities for the current version of OpenShift Container Platform. The default value is **vCurrent**.	String
capabilities.additionalEnabledCapabilities	Extends the set of optional capabilities beyond what you specify in **baselineCapabilitySet**. Valid values are **baremetal**, **marketplace** and **openshift-samples**. You may specify multiple capabilities in this parameter.	String array
cgroupsV2	Enables Linux control groups version 2 (cgroups v2) on specific nodes in your cluster. The OpenShift Container Platform process for enabling cgroups v2 disables all cgroup version 1 controllers and hierarchies. The OpenShift Container Platform cgroups version 2 feature is in Developer Preview and is not supported by Red Hat at this time.	**true**
compute	The configuration for the machines that comprise the compute nodes.	Array of **MachinePool** objects.
compute.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** (the default).	String
compute.name	Required if you use **compute**. The name of the machine pool.	**worker**

Parameter	Description	Values
compute.platform	Required if you use **compute**. Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the **controlPlane.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
compute.replicas	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to **2**. The default value is **3**.
controlPlane	The configuration for the machines that comprise the control plane.	Array of **MachinePool** objects.
controlPlane.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** (the default).	String
controlPlane.name	Required if you use **controlPlane**. The name of the machine pool.	**master**
controlPlane.platform	Required if you use **controlPlane**. Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the **compute.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
controlPlane.replicas	The number of control plane machines to provision.	The only supported value is **3**, which is the default value.

Parameter	Description	Values
credentialsMode	The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported.  **NOTE** Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the *Cloud Credential Operator* entry in the *Cluster Operators reference* content.  **NOTE** If your AWS account has service control policies (SCP) enabled, you must configure the **credentialsMode** parameter to **Mint**, **Passthrough** or **Manual**.	**Mint**, **Passthrough**, **Manual** or an empty string (**""**).

Parameter	Description	Values
fips	Enable or disable FIPS mode. The default is **false** (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.  **IMPORTANT** To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.  **NOTE** If you are using Azure File storage, you cannot enable FIPS mode.	**false** or **true**
imageContentSources	Sources and repositories for the release-image content.	Array of objects. Includes a **source** and, optionally, **mirrors**, as described in the following rows of this table.
imageContentSources.source	Required if you use **imageContentSources**. Specify the repository that users refer to, for example, in image pull specifications.	String
imageContentSources.mirrors	Specify one or more repositories that may also contain the same images.	Array of strings

Parameter	Description	Values
publish	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	**Internal** or **External**. The default value is **External**. Setting this field to **Internal** is not supported on non-cloud platforms and IBM Cloud VPC.  **IMPORTANT** If the value of the field is set to **Internal**, the cluster will become non-functional. For more information, refer to BZ#1953035.
sshKey	The SSH key to authenticate access to your cluster machines.  **NOTE** For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.	For example, **sshKey: ssh-ed25519 AAAA..**.

21.4.10.1.4. Additional VMware vSphere configuration parameters

Additional VMware vSphere configuration parameters are described in the following table:

Table 21.29. Additional VMware vSphere cluster parameters

Parameter	Description	Values
platform: vsphere vCenter	The fully-qualified hostname or IP address of the vCenter server.	String
platform: vsphere username	The user name to use to connect to the vCenter instance with. This user must have at least the roles and privileges that are required for static or dynamic persistent volume provisioning in vSphere.	String

Parameter	Description	Values
platform: vsphere password	The password for the vCenter user name.	String
platform: vsphere datacenter	The name of the datacenter to use in the vCenter instance.	String
platform: vsphere defaultDatastore	The name of the default datastore to use for provisioning volumes.	String
platform: vsphere folder	Optional. The absolute path of an existing folder where the installation program creates the virtual machines. If you do not provide this value, the installation program creates a folder that is named with the infrastructure ID in the datacenter virtual machine folder.	String, for example, **/<datacenter_name>/vm/<folder_name>/<subfolder_name>**.
platform: vsphere resourcePool	Optional. The absolute path of an existing resource pool where the installer creates the virtual machines. If you do not specify a value, resources are installed in the root of the cluster **/<datacenter_name>/host/<cluster_name>/Resources**.	String, for example, **/<datacenter_name>/host/<cluster_name>/Resources/<resource_pool_name>/<optional_nested_resource_pool_name>**.
platform: vsphere network	The network in the vCenter instance that contains the virtual IP addresses and DNS records that you configured.	String
platform: vsphere cluster	The vCenter cluster to install the OpenShift Container Platform cluster in.	String
platform: vsphere apiVIP	The virtual IP (VIP) address that you configured for control plane API access.	An IP address, for example **128.0.0.1**.

Parameter	Description	Values
platform: vsphere ingressVIP	The virtual IP (VIP) address that you configured for cluster ingress.	An IP address, for example **128.0.0.1**.
platform: vsphere diskType	Optional. The disk provisioning method. This value defaults to the vSphere default storage policy if not set.	Valid values are **thin**, **thick**, or **eagerZeroedThick**.

21.4.10.1.5. Optional VMware vSphere machine pool configuration parameters

Optional VMware vSphere machine pool configuration parameters are described in the following table:

Table 21.30. Optional VMware vSphere machine pool parameters

Parameter	Description	Values
platform: vsphere clusterOSImage	The location from which the installer downloads the RHCOS image. You must set this parameter to perform an installation in a restricted network.	An HTTP or HTTPS URL, optionally with a SHA-256 checksum. For example, **https://mirror.openshift.com/images/rhcos-<version>-vmware.<architecture>.ova**.
platform vsphere osDisk diskSizeGB	The size of the disk in gigabytes.	Integer
platform vsphere cpus	The total number of virtual processor cores to assign a virtual machine. The value of **platform.vsphere.cpus** must be a multiple of **platform.vsphere.coresPerSocket** value.	Integer
platform vsphere coresPerSocket	The number of cores per socket in a virtual machine. The number of virtual sockets on the virtual machine is **platform.vsphere.cpus**/**platform.vsphere.coresPerSocket**. The default value for control plane nodes and worker nodes is **4** and **2**, respectively.	Integer

Parameter	Description	Values
platform vsphere memoryMB	The size of a virtual machine's memory in megabytes.	Integer

21.4.10.2. Sample install-config.yaml file for an installer-provisioned VMware vSphere cluster

You can customize the install-config.yaml file to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.

```
apiVersion: v1
baseDomain: example.com 1
compute: 2
  name: worker
  replicas: 3
  platform:
    vsphere: 3
      cpus: 2
      coresPerSocket: 2
      memoryMB: 8192
      osDisk:
        diskSizeGB: 120
controlPlane: 4
  name: master
  replicas: 3
  platform:
    vsphere: 5
      cpus: 4
      coresPerSocket: 2
      memoryMB: 16384
      osDisk:
        diskSizeGB: 120
metadata:
  name: cluster 6
networking:
  clusterNetwork:
  - cidr: 10.128.0.0/14
    hostPrefix: 23
  machineNetwork:
  - cidr: 10.0.0.0/16
  networkType: OpenShiftSDN
  serviceNetwork:
  - 172.30.0.0/16
platform:
  vsphere:
    vcenter: your.vcenter.server
    username: username
    password: password
```

```
    datacenter: datacenter
    defaultDatastore: datastore
    folder: folder
    resourcePool: resource_pool (7)
    diskType: thin (8)
    network: VM_Network
    cluster: vsphere_cluster_name (9)
    apiVIP: api_vip
    ingressVIP: ingress_vip
fips: false
pullSecret: '{"auths": ...}'
sshKey: 'ssh-ed25519 AAAA...'
```

1. The base domain of the cluster. All DNS records must be sub-domains of this base and include the cluster name.

2 4. The **controlPlane** section is a single mapping, but the **compute** section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, **-**, and the first line of the **controlPlane** section must not. Only one control plane pool is used.

3 5. Optional: Provide additional configuration for the machine pool parameters for the compute and control plane machines.

6. The cluster name that you specified in your DNS records.

7. Optional: Provide an existing resource pool for machine creation. If you do not specify a value, the installation program uses the root resource pool of the vSphere cluster.

8. The vSphere disk provisioning method.

9. The vSphere cluster to install the OpenShift Container Platform cluster in.

21.4.10.3. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.

NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

Procedure

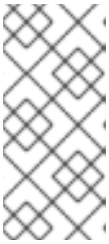
1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
```

1. A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
2. A proxy URL to use for creating HTTPS connections outside the cluster.
3. A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use ***** to bypass the proxy for all destinations. You must include vCenter's IP address and the IP range that you use for its machines.
4. If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace that contains one or more additional CA certificates that are required for proxying HTTPS connections. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges these contents with the Red Hat Enterprise Linux CoreOS (RHCOS) trust bundle, and this config map is referenced in the **trustedCA** field of the **Proxy** object. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.

NOTE

The installation program does not support the proxy **readinessEndpoints** field.



NOTE

If the installer times out, restart and then complete the deployment by using the **wait-for** command of the installer. For example:

```
$ ./openshift-install wait-for install-complete --log-level debug
```

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.

NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

21.4.11. Network configuration phases

There are two phases prior to OpenShift Container Platform installation where you can customize the network configuration.

Phase 1

You can customize the following network-related fields in the **install-config.yaml** file before you create the manifest files:

- **networking.networkType**
- **networking.clusterNetwork**
- **networking.serviceNetwork**
- **networking.machineNetwork**
  For more information on these fields, refer to *Installation configuration parameters*.

NOTE

Set the **networking.machineNetwork** to match the CIDR that the preferred NIC resides in.

IMPORTANT

The CIDR range **172.17.0.0/16** is reserved by libVirt. You cannot use this range or any range that overlaps with this range for any networks in your cluster.

Phase 2

After creating the manifest files by running **openshift-install create manifests**, you can define a customized Cluster Network Operator manifest with only the fields you want to modify. You can use the manifest to specify advanced network configuration.

You cannot override the values specified in phase 1 in the **install-config.yaml** file during phase 2. However, you can further customize the cluster network provider during phase 2.

21.4.12. Specifying advanced network configuration

You can use advanced network configuration for your cluster network provider to integrate your cluster into your existing network environment. You can specify advanced network configuration only before you install the cluster.

IMPORTANT

Customizing your network configuration by modifying the OpenShift Container Platform manifest files created by the installation program is not supported. Applying a manifest file that you create, as in the following procedure, is supported.

Prerequisites

- You have created the **install-config.yaml** file and completed any modifications to it.

Procedure

1. Change to the directory that contains the installation program and create the manifests:

```
$ ./openshift-install create manifests --dir <installation_directory> 1
```

1 **<installation_directory>** specifies the name of the directory that contains the **install-config.yaml** file for your cluster.

2. Create a stub manifest file for the advanced network configuration that is named **cluster-network-03-config.yml** in the **<installation_directory>/manifests/** directory:

```
apiVersion: operator.openshift.io/v1
kind: Network
metadata:
  name: cluster
spec:
```

3. Specify the advanced network configuration for your cluster in the **cluster-network-03-config.yml** file, such as in the following examples:

Specify a different VXLAN port for the OpenShift SDN network provider

```
apiVersion: operator.openshift.io/v1
kind: Network
metadata:
  name: cluster
spec:
  defaultNetwork:
    openshiftSDNConfig:
      vxlanPort: 4800
```

Enable IPsec for the OVN-Kubernetes network provider

```
apiVersion: operator.openshift.io/v1
kind: Network
metadata:
  name: cluster
spec:
  defaultNetwork:
    ovnKubernetesConfig:
      ipsecConfig: {}
```

4. Optional: Back up the **manifests/cluster-network-03-config.yml** file. The installation program consumes the **manifests/** directory when you create the Ignition config files.

21.4.13. Cluster Network Operator configuration

The configuration for the cluster network is specified as part of the Cluster Network Operator (CNO) configuration and stored in a custom resource (CR) object that is named **cluster**. The CR specifies the fields for the **Network** API in the **operator.openshift.io** API group.

The CNO configuration inherits the following fields during cluster installation from the **Network** API in the **Network.config.openshift.io** API group and these fields cannot be changed:

clusterNetwork

IP address pools from which pod IP addresses are allocated.

serviceNetwork

IP address pool for services.

defaultNetwork.type

Cluster network provider, such as OpenShift SDN or OVN-Kubernetes.

You can specify the cluster network provider configuration for your cluster by setting the fields for the **defaultNetwork** object in the CNO object named **cluster**.

21.4.13.1. Cluster Network Operator configuration object

The fields for the Cluster Network Operator (CNO) are described in the following table:

Table 21.31. Cluster Network Operator configuration object

Field	Type	Description
metadata.name	**string**	The name of the CNO object. This name is always **cluster**.

Field	Type	Description
spec.clusterNetwork	**array**	A list specifying the blocks of IP addresses from which pod IP addresses are allocated and the subnet prefix length assigned to each individual node in the cluster. For example: spec: clusterNetwork: - cidr: 10.128.0.0/19 hostPrefix: 23 - cidr: 10.128.32.0/19 hostPrefix: 23 You can customize this field only in the **install-config.yaml** file before you create the manifests. The value is read-only in the manifest file.
spec.serviceNetwork	**array**	A block of IP addresses for services. The OpenShift SDN and OVN-Kubernetes Container Network Interface (CNI) network providers support only a single IP address block for the service network. For example: spec: serviceNetwork: - 172.30.0.0/14 You can customize this field only in the **install-config.yaml** file before you create the manifests. The value is read-only in the manifest file.
spec.defaultNetwork	**object**	Configures the Container Network Interface (CNI) cluster network provider for the cluster network.
spec.kubeProxyConfig	**object**	The fields for this object specify the kube-proxy configuration. If you are using the OVN-Kubernetes cluster network provider, the kube-proxy configuration has no effect.

defaultNetwork object configuration

The values for the **defaultNetwork** object are defined in the following table:

Table 21.32. **defaultNetwork** object

Field	Type	Description

Field	Type	Description
type	**string**	Either **OpenShiftSDN** or **OVNKubernetes**. The cluster network provider is selected during installation. This value cannot be changed after cluster installation.  **NOTE** OpenShift Container Platform uses the OpenShift SDN Container Network Interface (CNI) cluster network provider by default.
openshiftSDNConfig	**object**	This object is only valid for the OpenShift SDN cluster network provider.
ovnKubernetesConfig	**object**	This object is only valid for the OVN-Kubernetes cluster network provider.

Configuration for the OpenShift SDN CNI cluster network provider
The following table describes the configuration fields for the OpenShift SDN Container Network Interface (CNI) cluster network provider.

Table 21.33. **openshiftSDNConfig** object

Field	Type	Description
mode	**string**	Configures the network isolation mode for OpenShift SDN. The default value is **NetworkPolicy**. The values **Multitenant** and **Subnet** are available for backwards compatibility with OpenShift Container Platform 3.x but are not recommended. This value cannot be changed after cluster installation.

Field	Type	Description
mtu	**integer**	The maximum transmission unit (MTU) for the VXLAN overlay network. This is detected automatically based on the MTU of the primary network interface. You do not normally need to override the detected MTU. If the auto-detected value is not what you expect it to be, confirm that the MTU on the primary network interface on your nodes is correct. You cannot use this option to change the MTU value of the primary network interface on the nodes. If your cluster requires different MTU values for different nodes, you must set this value to **50** less than the lowest MTU value in your cluster. For example, if some nodes in your cluster have an MTU of **9001**, and some have an MTU of**1500**, you must set this value to **1450**. This value cannot be changed after cluster installation.
vxlanPort	**integer**	The port to use for all VXLAN packets. The default value is **4789**. This value cannot be changed after cluster installation. If you are running in a virtualized environment with existing nodes that are part of another VXLAN network, then you might be required to change this. For example, when running an OpenShift SDN overlay on top of VMware NSX-T, you must select an alternate port for the VXLAN, because both SDNs use the same default VXLAN port number. On Amazon Web Services (AWS), you can select an alternate port for the VXLAN between port **9000** and port **9999**.

Example OpenShift SDN configuration

```
defaultNetwork:
  type: OpenShiftSDN
  openshiftSDNConfig:
    mode: NetworkPolicy
    mtu: 1450
    vxlanPort: 4789
```

Configuration for the OVN-Kubernetes CNI cluster network provider

The following table describes the configuration fields for the OVN-Kubernetes CNI cluster network provider.

Table 21.34. ovnKubernetesConfig object

Field	Type	Description

Field	Type	Description
mtu	**integer**	The maximum transmission unit (MTU) for the Geneve (Generic Network Virtualization Encapsulation) overlay network. This is detected automatically based on the MTU of the primary network interface. You do not normally need to override the detected MTU. If the auto-detected value is not what you expect it to be, confirm that the MTU on the primary network interface on your nodes is correct. You cannot use this option to change the MTU value of the primary network interface on the nodes. If your cluster requires different MTU values for different nodes, you must set this value to **100** less than the lowest MTU value in your cluster. For example, if some nodes in your cluster have an MTU of **9001**, and some have an MTU of**1500**, you must set this value to **1400**.
genevePort	**integer**	The port to use for all Geneve packets. The default value is **6081**. This value cannot be changed after cluster installation.
ipsecConfig	**object**	Specify an empty object to enable IPsec encryption.
policyAuditConfig	**object**	Specify a configuration object for customizing network policy audit logging. If unset, the defaults audit log settings are used.
gatewayConfig	**object**	Optional: Specify a configuration object for customizing how egress traffic is sent to the node gateway.  NOTE While migrating egress traffic, you can expect some disruption to workloads and service traffic until the Cluster Network Operator (CNO) successfully rolls out the changes.

Table 21.35. **policyAuditConfig** object

Field	Type	Description
rateLimit	integer	The maximum number of messages to generate every second per node. The default value is **20** messages per second.
maxFileSize	integer	The maximum size for the audit log in bytes. The default value is **50000000** or 50 MB.

Field	Type	Description
destination	string	One of the following additional audit log targets: **libc** The libc **syslog()** function of the journald process on the host. **udp:<host>:<port>** A syslog server. Replace **<host>:<port>** with the host and port of the syslog server. **unix:<file>** A Unix Domain Socket file specified by **<file>**. **null** Do not send the audit logs to any additional target.
syslogFacility	string	The syslog facility, such as **kern**, as defined by RFC5424. The default value is **local0**.

Table 21.36. **gatewayConfig** object

Field	Type	Description
routingViaHost	**boolean**	Set this field to **true** to send egress traffic from pods to the host networking stack. For highly-specialized installations and applications that rely on manually configured routes in the kernel routing table, you might want to route egress traffic to the host networking stack. By default, egress traffic is processed in OVN to exit the cluster and is not affected by specialized routes in the kernel routing table. The default value is **false**. This field has an interaction with the Open vSwitch hardware offloading feature. If you set this field to **true**, you do not receive the performance benefits of the offloading because egress traffic is processed by the host networking stack.

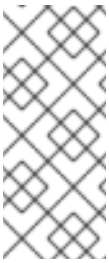
Example OVN-Kubernetes configuration with IPSec enabled

```
defaultNetwork:
  type: OVNKubernetes
  ovnKubernetesConfig:
    mtu: 1400
    genevePort: 6081
    ipsecConfig: {}
```

kubeProxyConfig object configuration

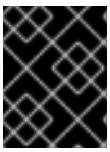
The values for the **kubeProxyConfig** object are defined in the following table:

Table 21.37. **kubeProxyConfig** object

Field	Type	Description
iptablesSyncPeriod	**string**	The refresh period for **iptables** rules. The default value is **30s**. Valid suffixes include **s**, **m**, and **h** and are described in the Go **time** package documentation.  **NOTE** Because of performance improvements introduced in OpenShift Container Platform 4.3 and greater, adjusting the **iptablesSyncPeriod** parameter is no longer necessary.
proxyArguments.iptables-min-sync-period	**array**	The minimum duration before refreshing **iptables** rules. This field ensures that the refresh does not happen too frequently. Valid suffixes include **s**, **m**, and **h** and are described in the Go **time** package. The default value is: `kubeProxyConfig:` `  proxyArguments:` `  iptables-min-sync-period:` `  - 0s`

21.4.14. Deploying the cluster

You can install OpenShift Container Platform on a compatible cloud platform.



IMPORTANT

You can run the **create cluster** command of the installation program only once, during initial installation.

Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.

Procedure

- Change to the directory that contains the installation program and initialize the cluster deployment:

```
$ ./openshift-install create cluster --dir <installation_directory> \ 1
    --log-level=info 2
```

1 For **<installation_directory>**, specify the location of your customized **./install-config.yaml** file.

2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

Verification

When the cluster deployment completes successfully:

- The terminal displays directions for accessing your cluster, including a link to the web console and credentials for the **kubeadmin** user.
- Credential information also outputs to **<installation_directory>/.openshift_install.log**.

IMPORTANT

Do not delete the installation program or the files that the installation program creates. Both are required to delete the cluster.

Example output

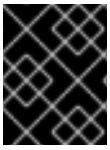
```
...
INFO Install complete!
INFO To access the cluster as the system:admin user when using 'oc', run 'export
KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
INFO Access the OpenShift web-console here: https://console-openshift-
console.apps.mycluster.example.com
INFO Login to the console with user: "kubeadmin", and password: "password"
INFO Time elapsed: 36m22s
```

IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

21.4.15. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.



IMPORTANT

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.11. Download and install the new version of **oc**.

Installing the OpenShift CLI on Linux

You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the architecture in the **Product Variant** drop-down menu.
3. Select the appropriate version in the **Version** drop-down menu.
4. Click **Download Now** next to the **OpenShift v4.11 Linux Client** entry and save the file.
5. Unpack the archive:

```
$ tar xvf <file>
```

6. Place the **oc** binary in a directory that is on your **PATH**.
   To check your **PATH**, execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.
   To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
C:\> oc <command>
```

Installing the OpenShift CLI on macOS

You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 macOS Client** entry and save the file.

NOTE

For macOS arm64, choose the **OpenShift v4.11 macOS arm64 Client** entry.

4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your PATH.
   To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

21.4.16. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

1. For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

Example output

```
system:admin
```

21.4.17. Creating registry storage

After you install the cluster, you must create storage for the registry Operator.

21.4.17.1. Image registry removed during installation

On platforms that do not provide shareable object storage, the OpenShift Image Registry Operator bootstraps itself as **Removed**. This allows **openshift-installer** to complete installations on these platform types.

After installation, you must edit the Image Registry Operator configuration to switch the **managementState** from **Removed** to **Managed**.

21.4.17.2. Image registry storage configuration

The Image Registry Operator is not initially available for platforms that do not provide default storage. After installation, you must configure your registry to use storage so that the Registry Operator is made available.

Instructions are shown for configuring a persistent volume, which is required for production clusters. Where applicable, instructions are shown for configuring an empty directory as the storage location, which is available for only non-production clusters.

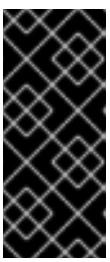
Additional instructions are provided for allowing the image registry to use block storage types by using the **Recreate** rollout strategy during upgrades.

21.4.17.2.1. Configuring registry storage for VMware vSphere

As a cluster administrator, following installation you must configure your registry to use storage.

Prerequisites

- Cluster administrator permissions.
- A cluster on VMware vSphere.
- Persistent storage provisioned for your cluster, such as Red Hat OpenShift Data Foundation.



IMPORTANT

OpenShift Container Platform supports **ReadWriteOnce** access for image registry storage when you have only one replica. **ReadWriteOnce** access also requires that the registry uses the **Recreate** rollout strategy. To deploy an image registry that supports high availability with two or more replicas, **ReadWriteMany** access is required.

- Must have "100Gi" capacity.

IMPORTANT

Testing shows issues with using the NFS server on RHEL as storage backend for core services. This includes the OpenShift Container Registry and Quay, Prometheus for monitoring storage, and Elasticsearch for logging storage. Therefore, using RHEL NFS to back PVs used by core services is not recommended.

Other NFS implementations on the marketplace might not have these issues. Contact the individual NFS implementation vendor for more information on any testing that was possibly completed against these OpenShift Container Platform core components.

Procedure

1. To configure your registry to use storage, change the **spec.storage.pvc** in the **configs.imageregistry/cluster** resource.

NOTE

When you use shared storage, review your security settings to prevent outside access.

2. Verify that you do not have a registry pod:

```
$ oc get pod -n openshift-image-registry -l docker-registry=default
```

Example output

```
No resourses found in openshift-image-registry namespace
```

NOTE

If you do have a registry pod in your output, you do not need to continue with this procedure.

3. Check the registry configuration:

```
$ oc edit configs.imageregistry.operator.openshift.io
```

Example output

```
storage:
  pvc:
    claim: 1
```

1 Leave the **claim** field blank to allow the automatic creation of an **image-registry-storage** persistent volume claim (PVC). The PVC is generated based on the default storage class. However, be aware that the default storage class might provide ReadWriteOnce (RWO) volumes, such as a RADOS Block Device (RBD), which can cause issues when you replicate to more than one replica.

4. Check the **clusteroperator** status:

```
$ oc get clusteroperator image-registry
```

Example output

```
NAME              VERSION                             AVAILABLE   PROGRESSING   DEGRADED
SINCE   MESSAGE
image-registry    4.7                                 True        False         False     6h50m
```

21.4.17.2.2. Configuring block registry storage for VMware vSphere

To allow the image registry to use block storage types such as vSphere Virtual Machine Disk (VMDK) during upgrades as a cluster administrator, you can use the **Recreate** rollout strategy.

IMPORTANT

Block storage volumes are supported but not recommended for use with image registry on production clusters. An installation where the registry is configured on block storage is not highly available because the registry cannot have more than one replica.

Procedure

1. Enter the following command to set the image registry storage as a block storage type, patch the registry so that it uses the **Recreate** rollout strategy, and runs with only **1** replica:

```
$ oc patch config.imageregistry.operator.openshift.io/cluster --type=merge -p '{"spec":
{"rolloutStrategy":"Recreate","replicas":1}}'
```

2. Provision the PV for the block storage device, and create a PVC for that volume. The requested block volume uses the ReadWriteOnce (RWO) access mode.

   a. Create a **pvc.yaml** file with the following contents to define a VMware vSphere **PersistentVolumeClaim** object:

```
kind: PersistentVolumeClaim
apiVersion: v1
metadata:
  name: image-registry-storage 1
  namespace: openshift-image-registry 2
spec:
  accessModes:
  - ReadWriteOnce 3
  resources:
    requests:
      storage: 100Gi 4
```

1. A unique name that represents the **PersistentVolumeClaim** object.
2. The namespace for the **PersistentVolumeClaim** object, which is **openshift-image-registry**.
3. The access mode of the persistent volume claim. With **ReadWriteOnce**, the volume can be mounted with read and write permissions by a single node.

4 The size of the persistent volume claim.

b. Enter the following command to create the **PersistentVolumeClaim** object from the file:

```
$ oc create -f pvc.yaml -n openshift-image-registry
```

3. Enter the following command to edit the registry configuration so that it references the correct PVC:

```
$ oc edit config.imageregistry.operator.openshift.io -o yaml
```

Example output

```
storage:
  pvc:
    claim: 1
```

1 By creating a custom PVC, you can leave the **claim** field blank for the default automatic creation of an **image-registry-storage** PVC.

For instructions about configuring registry storage so that it references the correct PVC, see Configuring the registry for vSphere.

21.4.18. Backing up VMware vSphere volumes

OpenShift Container Platform provisions new volumes as independent persistent disks to freely attach and detach the volume on any node in the cluster. As a consequence, it is not possible to back up volumes that use snapshots, or to restore volumes from snapshots. See Snapshot Limitations for more information.

Procedure

To create a backup of persistent volumes:

1. Stop the application that is using the persistent volume.
2. Clone the persistent volume.
3. Restart the application.
4. Create a backup of the cloned volume.
5. Delete the cloned volume.

21.4.19. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.11, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to OpenShift Cluster Manager Hybrid Cloud Console.

After you confirm that your OpenShift Cluster Manager Hybrid Cloud Console inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, use

subscription watch to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

Additional resources

- See About remote health monitoring for more information about the Telemetry service

21.4.20. Configuring an external load balancer

You can configure an OpenShift Container Platform cluster to use an external load balancer in place of the default load balancer.

IMPORTANT

Configuring an external load balancer depends on your vendor's load balancer.

The information and examples in this section are for guideline purposes only. Consult the vendor documentation for more specific information about the vendor's load balancer.

Red Hat supports the following services for an external load balancer:

- Ingress Controller
- OpenShift API
- OpenShift MachineConfig API

You can choose whether you want to configure one or all of these services for an external load balancer. Configuring only the Ingress Controller service is a common configuration option. To better understand each service, view the following diagrams:

Figure 21.7. Example network workflow that shows an Ingress Controller operating in an OpenShift Container Platform environment

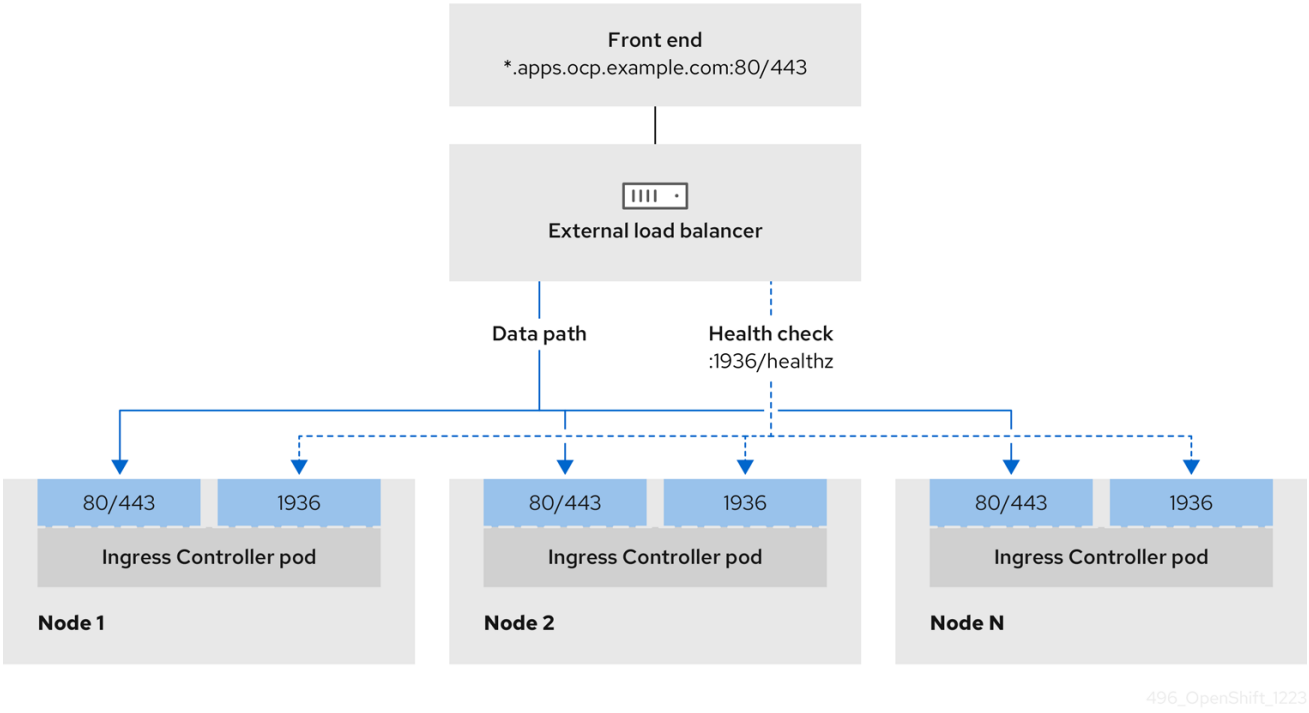


Figure 21.8. Example network workflow that shows an OpenShift API operating in an OpenShift Container Platform environment

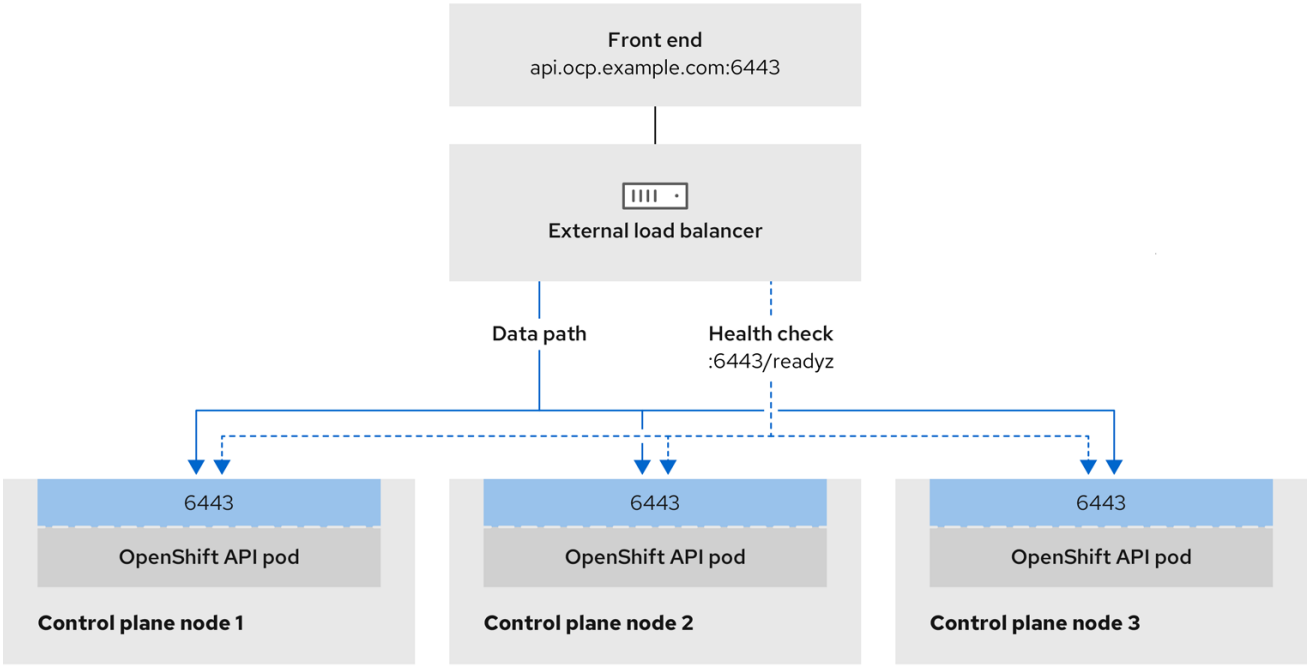
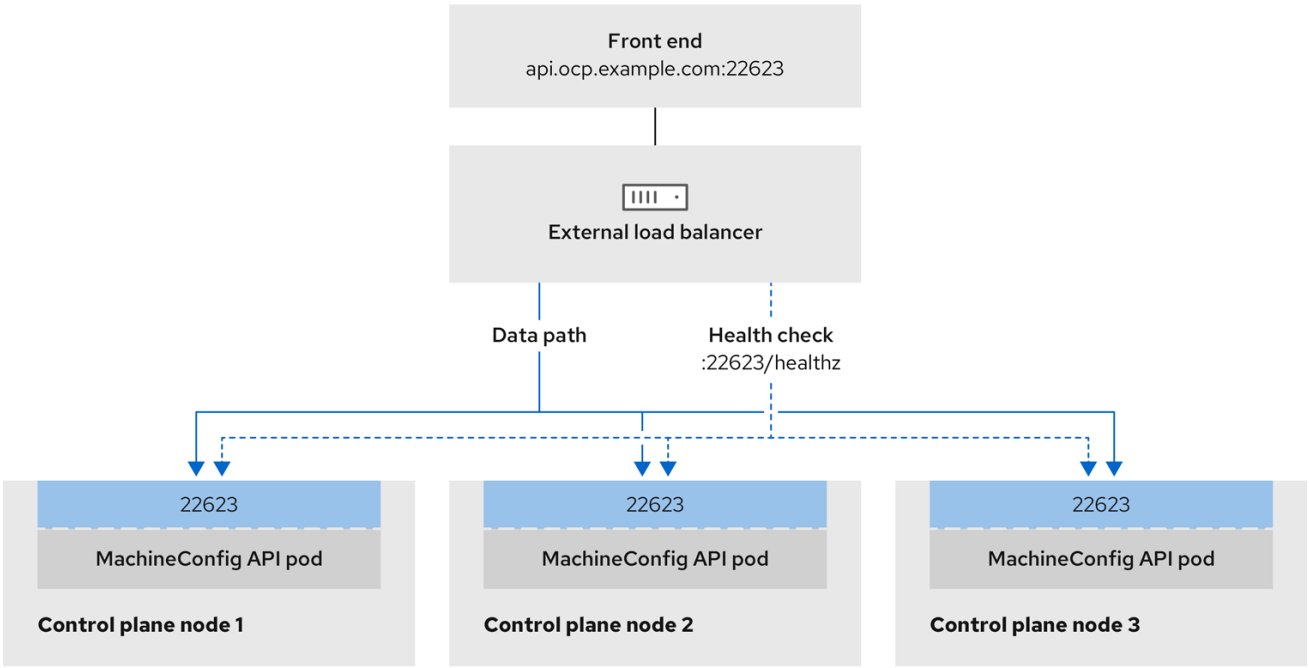


Figure 21.9. Example network workflow that shows an OpenShift MachineConfig API operating in an OpenShift Container Platform environment



Considerations

- For a front-end IP address, you can use the same IP address for the front-end IP address, the Ingress Controller's load balancer, and API load balancer. Check the vendor's documentation for this capability.

- For a back-end IP address, ensure that an IP address for an OpenShift Container Platform control plane node does not change during the lifetime of the external load balancer. You can achieve this by completing one of the following actions:
  - Assign a static IP address to each control plane node.
  - Configure each node to receive the same IP address from the DHCP every time the node requests a DHCP lease. Depending on the vendor, the DHCP lease might be in the form of an IP reservation or a static DHCP assignment.
- Manually define each node that runs the Ingress Controller in the external load balancer for the Ingress Controller back-end service. For example, if the Ingress Controller moves to an undefined node, a connection outage can occur.

OpenShift API prerequisites

- You defined a front-end IP address.
- TCP ports 6443 and 22623 are exposed on the front-end IP address of your load balancer. Check the following items:
  - Port 6443 provides access to the OpenShift API service.
  - Port 22623 can provide ignition startup configurations to nodes.
- The front-end IP address and port 6443 are reachable by all users of your system with a location external to your OpenShift Container Platform cluster.
- The front-end IP address and port 22623 are reachable only by OpenShift Container Platform nodes.
- The load balancer backend can communicate with OpenShift Container Platform control plane nodes on port 6443 and 22623.

Ingress Controller prerequisites

- You defined a front-end IP address.
- TCP ports 443 and 80 are exposed on the front-end IP address of your load balancer.
- The front-end IP address, port 80 and port 443 are be reachable by all users of your system with a location external to your OpenShift Container Platform cluster.
- The front-end IP address, port 80 and port 443 are reachable to all nodes that operate in your OpenShift Container Platform cluster.
- The load balancer backend can communicate with OpenShift Container Platform nodes that run the Ingress Controller on ports 80, 443, and 1936.

Prerequisite for health check URL specifications

You can configure most load balancers by setting health check URLs that determine if a service is available or unavailable. OpenShift Container Platform provides these health checks for the OpenShift API, Machine Configuration API, and Ingress Controller backend services.

The following examples demonstrate health check specifications for the previously listed backend services:

Example of a Kubernetes API health check specification

```
Path: HTTPS:6443/readyz
Healthy threshold: 2
Unhealthy threshold: 2
Timeout: 10
Interval: 10
```

Example of a Machine Config API health check specification

```
Path: HTTPS:22623/healthz
Healthy threshold: 2
Unhealthy threshold: 2
Timeout: 10
Interval: 10
```

Example of an Ingress Controller health check specification

```
Path: HTTP:1936/healthz/ready
Healthy threshold: 2
Unhealthy threshold: 2
Timeout: 5
Interval: 10
```

Procedure

1. Configure the HAProxy Ingress Controller, so that you can enable access to the cluster from your load balancer on ports 6443, 443, and 80:

   ### Example HAProxy configuration

   ```
   #...
   listen my-cluster-api-6443
       bind 192.168.1.100:6443
       mode tcp
       balance roundrobin
     option httpchk
     http-check connect
     http-check send meth GET uri /readyz
     http-check expect status 200
       server my-cluster-master-2 192.168.1.101:6443 check inter 10s rise 2 fall 2
       server my-cluster-master-0 192.168.1.102:6443 check inter 10s rise 2 fall 2
       server my-cluster-master-1 192.168.1.103:6443 check inter 10s rise 2 fall 2

   listen my-cluster-machine-config-api-22623
       bind 192.168.1.1000.0.0.0:22623
       mode tcp
       balance roundrobin
     option httpchk
     http-check connect
     http-check send meth GET uri /healthz
     http-check expect status 200
       server my-cluster-master-2 192.0168.21.2101:22623 check inter 10s rise 2 fall 2
       server my-cluster-master-0 192.168.1.1020.2.3:22623 check inter 10s rise 2 fall 2
   ```

```
    server my-cluster-master-1 192.168.1.1030.2.1:22623 check inter 10s rise 2 fall 2

listen my-cluster-apps-443
        bind 192.168.1.100:443
        mode tcp
        balance roundrobin
    option httpchk
    http-check connect
    http-check send meth GET uri /healthz/ready
    http-check expect status 200
        server my-cluster-worker-0 192.168.1.111:443 check port 1936 inter 10s rise 2 fall 2
        server my-cluster-worker-1 192.168.1.112:443 check port 1936 inter 10s rise 2 fall 2
        server my-cluster-worker-2 192.168.1.113:443 check port 1936 inter 10s rise 2 fall 2

listen my-cluster-apps-80
        bind 192.168.1.100:80
        mode tcp
        balance roundrobin
    option httpchk
    http-check connect
    http-check send meth GET uri /healthz/ready
    http-check expect status 200
        server my-cluster-worker-0 192.168.1.111:80 check port 1936 inter 10s rise 2 fall 2
        server my-cluster-worker-1 192.168.1.112:80 check port 1936 inter 10s rise 2 fall 2
        server my-cluster-worker-2 192.168.1.113:80 check port 1936 inter 10s rise 2 fall 2
# ...
```

2. Use the **curl** CLI command to verify that the external load balancer and its resources are operational:

   a. Verify that the cluster machine configuration API is accessible to the Kubernetes API server resource, by running the following command and observing the response:

      ```
      $ curl https://<loadbalancer_ip_address>:6443/version --insecure
      ```

      If the configuration is correct, you receive a JSON object in response:

      ```
      {
        "major": "1",
        "minor": "11+",
        "gitVersion": "v1.11.0+ad103ed",
        "gitCommit": "ad103ed",
        "gitTreeState": "clean",
        "buildDate": "2019-01-09T06:44:10Z",
        "goVersion": "go1.10.3",
        "compiler": "gc",
        "platform": "linux/amd64"
      }
      ```

   b. Verify that the cluster machine configuration API is accessible to the Machine config server resource, by running the following command and observing the output:

      ```
      $ curl -v https://<loadbalancer_ip_address>:22623/healthz --insecure
      ```

      If the configuration is correct, the output from the command shows the following response:

```
HTTP/1.1 200 OK
Content-Length: 0
```

c. Verify that the controller is accessible to the Ingress Controller resource on port 80, by running the following command and observing the output:

```
$ curl -I -L -H "Host: console-openshift-console.apps.<cluster_name>.<base_domain>"
http://<load_balancer_front_end_IP_address>
```

If the configuration is correct, the output from the command shows the following response:

```
HTTP/1.1 302 Found
content-length: 0
location: https://console-openshift-console.apps.ocp4.private.opequon.net/
cache-control: no-cache
```

d. Verify that the controller is accessible to the Ingress Controller resource on port 443, by running the following command and observing the output:

```
$ curl -I -L --insecure --resolve console-openshift-console.apps.<cluster_name>.
<base_domain>:443:<Load Balancer Front End IP Address> https://console-openshift-
console.apps.<cluster_name>.<base_domain>
```

If the configuration is correct, the output from the command shows the following response:

```
HTTP/1.1 200 OK
referrer-policy: strict-origin-when-cross-origin
set-cookie: csrf-
token=UlYWOyQ62LWjw2h003xtYSKlh1a0Py2hhctw0WmV2YEdhJjFyQwWcGBsja261dG
LgaYO0nxzVErhiXt6QepA7g==; Path=/; Secure; SameSite=Lax
x-content-type-options: nosniff
x-dns-prefetch-control: off
x-frame-options: DENY
x-xss-protection: 1; mode=block
date: Wed, 04 Oct 2023 16:29:38 GMT
content-type: text/html; charset=utf-8
set-cookie:
1e2670d92730b515ce3a1bb65da45062=1bf5e9573c9a2760c964ed1659cc1673; path=/;
HttpOnly; Secure; SameSite=None
cache-control: private
```

3. Configure the DNS records for your cluster to target the front-end IP addresses of the external load balancer. You must update records to your DNS server for the cluster API and applications over the load balancer.

Examples of modified DNS records

```
<load_balancer_ip_address>  A  api.<cluster_name>.<base_domain>
A record pointing to Load Balancer Front End
```

```
<load_balancer_ip_address>   A apps.<cluster_name>.<base_domain>
A record pointing to Load Balancer Front End
```

IMPORTANT

DNS propagation might take some time for each DNS record to become available. Ensure that each DNS record propagates before validating each record.

4. Use the **curl** CLI command to verify that the external load balancer and DNS record configuration are operational:

   a. Verify that you can access the cluster API, by running the following command and observing the output:

   ```
   $ curl https://api.<cluster_name>.<base_domain>:6443/version --insecure
   ```

   If the configuration is correct, you receive a JSON object in response:

   ```
   {
     "major": "1",
     "minor": "11+",
     "gitVersion": "v1.11.0+ad103ed",
     "gitCommit": "ad103ed",
     "gitTreeState": "clean",
     "buildDate": "2019-01-09T06:44:10Z",
     "goVersion": "go1.10.3",
     "compiler": "gc",
     "platform": "linux/amd64"
     }
   ```

   b. Verify that you can access the cluster machine configuration, by running the following command and observing the output:

   ```
   $ curl -v https://api.<cluster_name>.<base_domain>:22623/healthz --insecure
   ```

   If the configuration is correct, the output from the command shows the following response:

   ```
   HTTP/1.1 200 OK
   Content-Length: 0
   ```

   c. Verify that you can access each cluster application on port, by running the following command and observing the output:

   ```
   $ curl http://console-openshift-console.apps.<cluster_name>.<base_domain> -I -L --
   insecure
   ```

   If the configuration is correct, the output from the command shows the following response:

   ```
   HTTP/1.1 302 Found
   content-length: 0
   location: https://console-openshift-console.apps.<cluster-name>.<base domain>/
   cache-control: no-cacheHTTP/1.1 200 OK
   referrer-policy: strict-origin-when-cross-origin
   set-cookie: csrf-
   token=39HoZgztDnzjJkq/JuLJMeoKNXlfiVv2YgZc09c3TBOBU4NI6kDXaJH1LdicNhN1UsQ
   Wzon4Dor9GWGfopaTEQ==; Path=/; Secure
   ```

```
x-content-type-options: nosniff
x-dns-prefetch-control: off
x-frame-options: DENY
x-xss-protection: 1; mode=block
date: Tue, 17 Nov 2020 08:42:10 GMT
content-type: text/html; charset=utf-8
set-cookie:
1e2670d92730b515ce3a1bb65da45062=9b714eb87e93cf34853e87a92d6894be; path=/;
HttpOnly; Secure; SameSite=None
cache-control: private
```

d. Verify that you can access each cluster application on port 443, by running the following command and observing the output:

```
$ curl https://console-openshift-console.apps.<cluster_name>.<base_domain> -I -L --
insecure
```

If the configuration is correct, the output from the command shows the following response:

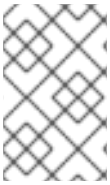
```
HTTP/1.1 200 OK
referrer-policy: strict-origin-when-cross-origin
set-cookie: csrf-
token=UlYWOyQ62LWjw2h003xtYSKlh1a0Py2hhctw0WmV2YEdhJjFyQwWcGBsja261dG
LgaYO0nxzVErhiXt6QepA7g==; Path=/; Secure; SameSite=Lax
x-content-type-options: nosniff
x-dns-prefetch-control: off
x-frame-options: DENY
x-xss-protection: 1; mode=block
date: Wed, 04 Oct 2023 16:29:38 GMT
content-type: text/html; charset=utf-8
set-cookie:
1e2670d92730b515ce3a1bb65da45062=1bf5e9573c9a2760c964ed1659cc1673; path=/;
HttpOnly; Secure; SameSite=None
cache-control: private
```

21.4.21. Next steps

- Customize your cluster.
- If necessary, you can opt out of remote health reporting .
- Set up your registry and configure registry storage .
- Optional: View the events from the vSphere Problem Detector Operator to determine if the cluster has permission or storage configuration issues.

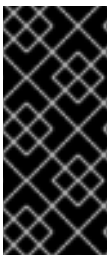
21.5. INSTALLING A CLUSTER ON VSPHERE WITH USER-PROVISIONED INFRASTRUCTURE

In OpenShift Container Platform version 4.11, you can install a cluster on VMware vSphere infrastructure that you provision.



NOTE

OpenShift Container Platform supports deploying a cluster to a single VMware vCenter only. Deploying a cluster with machines/machine sets on multiple vCenters is not supported.



IMPORTANT

The steps for performing a user-provisioned infrastructure installation are provided as an example only. Installing a cluster with infrastructure you provide requires knowledge of the vSphere platform and the installation process of OpenShift Container Platform. Use the user-provisioned infrastructure installation instructions as a guide; you are free to create the required resources through other methods.

21.5.1. Prerequisites

- You reviewed details about the OpenShift Container Platform installation and update processes.
- You read the documentation on selecting a cluster installation method and preparing it for users.
- You provisioned persistent storage for your cluster. To deploy a private image registry, your storage must provide **ReadWriteMany** access modes.
- Completing the installation requires that you upload the Red Hat Enterprise Linux CoreOS (RHCOS) OVA on vSphere hosts. The machine from which you complete this process requires access to port 443 on the vCenter and ESXi hosts. You verified that port 443 is accessible.
- If you use a firewall, you confirmed with the administrator that port 443 is accessible. Control plane nodes must be able to reach vCenter and ESXi hosts on port 443 for the installation to succeed.
- If you use a firewall, you configured it to allow the sites that your cluster requires access to.

NOTE

Be sure to also review this site list if you are configuring a proxy.

21.5.2. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.11, you require access to the internet to install your cluster.

You must have internet access to:

- Access OpenShift Cluster Manager Hybrid Cloud Console to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access Quay.io to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.

IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

21.5.3. VMware vSphere infrastructure requirements

You must install the OpenShift Container Platform cluster on a VMware vSphere version 7 instance that meets the requirements for the components that you use.

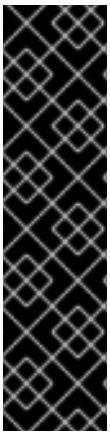
NOTE

OpenShift Container Platform version 4.11 does not support VMware vSphere version 8.0.

You can host the VMware vSphere infrastructure on-premise or on a VMware Cloud Verified provider that meets the requirements outlined in the following table:

Table 21.38. Version requirements for vSphere virtual environments

Virtual environment product	Required version
VM hardware version	15 or later
vSphere ESXi hosts	7
vCenter host	7



IMPORTANT

Installing a cluster on VMware vSphere version 7.0 Update 1 or earlier is now deprecated. These versions are still fully supported, but version 4.11 of OpenShift Container Platform requires vSphere virtual hardware version 15 or later. Hardware version 15 is now the default for vSphere virtual machines in OpenShift Container Platform. To update the hardware version for your vSphere nodes, see the "Updating hardware on nodes running in vSphere" article.

If your vSphere nodes are below hardware version 15 or your VMware vSphere version is earlier than 6.7.3, upgrading from OpenShift Container Platform 4.10 to OpenShift Container Platform 4.11 is not available.

Table 21.39. Minimum supported vSphere version for VMware components

Component	Minimum supported versions	Description

Component	Minimum supported versions	Description
Hypervisor	vSphere 7 with HW version 15	This version is the minimum version that Red Hat Enterprise Linux CoreOS (RHCOS) supports. For more information about supported hardware on the latest version of Red Hat Enterprise Linux (RHEL) that is compatible with RHCOS, see Hardware on the Red Hat Customer Portal.
Storage with in-tree drivers	vSphere 7	This plugin creates vSphere storage by using the in-tree storage drivers for vSphere included in OpenShift Container Platform.
Optional: Networking (NSX-T)	vSphere 7	vSphere 7 is required for OpenShift Container Platform. For more information about the compatibility of NSX and OpenShift Container Platform, see the Release Notes section of VMware's NSX container plugin documentation.

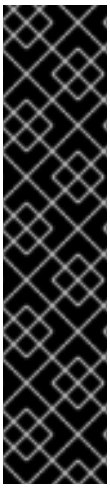
IMPORTANT

You must ensure that the time on your ESXi hosts is synchronized before you install OpenShift Container Platform. See Edit Time Configuration for a Host in the VMware documentation.

21.5.4. VMware vSphere CSI Driver Operator requirements

To install the vSphere CSI Driver Operator, the following requirements must be met:

- VMware vSphere version 7.0 Update 1 or later
- Virtual machines of hardware version 15 or later
- No third-party vSphere CSI driver already installed in the cluster



IMPORTANT

If a third-party vSphere CSI driver is present in the cluster, OpenShift Container Platform does not overwrite it. If you continue with the third-party vSphere CSI driver when upgrading to the next major version of OpenShift Container Platform, the **oc** CLI prompts you with the following message:

> VSphereCSIDriverOperatorCRUpgradeable: VMwareVSphereControllerUpgradeable: found existing unsupported csi.vsphere.vmware.com driver

The previous message informs you that Red Hat does not support the third-party vSphere CSI driver during an OpenShift Container Platform upgrade operation. You can choose to ignore this message and continue with the upgrade operation.

Additional resources

- To remove a third-party vSphere CSI driver, see Removing a third-party vSphere CSI Driver .
- To update the hardware version for your vSphere nodes, see Updating hardware on nodes running in vSphere.

21.5.5. Requirements for a cluster with user-provisioned infrastructure

For a cluster that contains user-provisioned infrastructure, you must deploy all of the required machines.

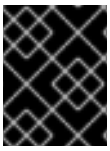
This section describes the requirements for deploying OpenShift Container Platform on user-provisioned infrastructure.

21.5.5.1. Required machines for cluster installation

The smallest OpenShift Container Platform clusters require the following hosts:

Table 21.40. Minimum required hosts

Hosts	Description
One temporary bootstrap machine	The cluster requires the bootstrap machine to deploy the OpenShift Container Platform cluster on the three control plane machines. You can remove the bootstrap machine after you install the cluster.
Three control plane machines	The control plane machines run the Kubernetes and OpenShift Container Platform services that form the control plane.
At least two compute machines, which are also known as worker machines.	The workloads requested by OpenShift Container Platform users run on the compute machines.



IMPORTANT

To maintain high availability of your cluster, use separate physical hosts for these cluster machines.

The bootstrap and control plane machines must use Red Hat Enterprise Linux CoreOS (RHCOS) as the operating system. However, the compute machines can choose between Red Hat Enterprise Linux CoreOS (RHCOS), Red Hat Enterprise Linux (RHEL) 8.6 and later.

Note that RHCOS is based on Red Hat Enterprise Linux (RHEL) 8 and inherits all of its hardware certifications and requirements. See Red Hat Enterprise Linux technology capabilities and limits .

21.5.5.2. Minimum resource requirements for cluster installation

Each cluster machine must meet the following minimum requirements:

Table 21.41. Minimum resource requirements

Machine	Operating System	vCPU	Virtual RAM	Storage	Input/Output Per Second (IOPS)[1]
Bootstrap	RHCOS	4	16 GB	100 GB	300
Control plane	RHCOS	4	16 GB	100 GB	300
Compute	RHCOS, RHEL 8.6 and later [2]	2	8 GB	100 GB	300

1. OpenShift Container Platform and Kubernetes are sensitive to disk performance, and faster storage is recommended, particularly for etcd on the control plane nodes which require a 10 ms p99 fsync duration. Note that on many cloud platforms, storage size and IOPS scale together, so you might need to over-allocate storage volume to obtain sufficient performance.

2. As with all user-provisioned installations, if you choose to use RHEL compute machines in your cluster, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks. Use of RHEL 7 compute machines is deprecated and has been removed in OpenShift Container Platform 4.10 and later.

If an instance type for your platform meets the minimum requirements for cluster machines, it is supported to use in OpenShift Container Platform.

Additional resources

- Optimizing storage

21.5.5.3. Certificate signing requests management

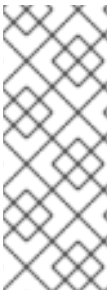
Because your cluster has limited access to automatic machine management when you use infrastructure that you provision, you must provide a mechanism for approving cluster certificate signing requests (CSRs) after installation. The **kube-controller-manager** only approves the kubelet client CSRs. The **machine-approver** cannot guarantee the validity of a serving certificate that is requested by using kubelet credentials because it cannot confirm that the correct machine issued the request. You must determine and implement a method of verifying the validity of the kubelet serving certificate requests and approving them.

21.5.5.4. Networking requirements for user-provisioned infrastructure

All the Red Hat Enterprise Linux CoreOS (RHCOS) machines require networking to be configured in **initramfs** during boot to fetch their Ignition config files.

During the initial boot, the machines require an IP address configuration that is set either through a DHCP server or statically by providing the required boot options. After a network connection is established, the machines download their Ignition config files from an HTTP or HTTPS server. The Ignition config files are then used to set the exact state of each machine. The Machine Config Operator completes more changes to the machines, such as the application of new certificates or keys, after installation.

It is recommended to use a DHCP server for long-term management of the cluster machines. Ensure that the DHCP server is configured to provide persistent IP addresses, DNS server information, and hostnames to the cluster machines.



NOTE

If a DHCP service is not available for your user-provisioned infrastructure, you can instead provide the IP networking configuration and the address of the DNS server to the nodes at RHCOS install time. These can be passed as boot arguments if you are installing from an ISO image. See the *Installing RHCOS and starting the OpenShift Container Platform bootstrap process* section for more information about static IP provisioning and advanced networking options.

The Kubernetes API server must be able to resolve the node names of the cluster machines. If the API servers and worker nodes are in different zones, you can configure a default DNS search zone to allow the API server to resolve the node names. Another supported approach is to always refer to hosts by their fully-qualified domain names in both the node objects and all DNS requests.

21.5.5.4.1. Setting the cluster node hostnames through DHCP

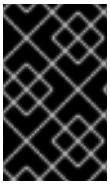
On Red Hat Enterprise Linux CoreOS (RHCOS) machines, the hostname is set through NetworkManager. By default, the machines obtain their hostname through DHCP. If the hostname is not provided by DHCP, set statically through kernel arguments, or another method, it is obtained through a reverse DNS lookup. Reverse DNS lookup occurs after the network has been initialized on a node and can take time to resolve. Other system services can start prior to this and detect the hostname as **localhost** or similar. You can avoid this by using DHCP to provide the hostname for each cluster node.

Additionally, setting the hostnames through DHCP can bypass any manual DNS record name configuration errors in environments that have a DNS split-horizon implementation.

21.5.5.4.2. Network connectivity requirements

You must configure the network connectivity between machines to allow OpenShift Container Platform cluster components to communicate. Each machine must be able to resolve the hostnames of all other machines in the cluster.

This section provides details about the ports that are required.



IMPORTANT

In connected OpenShift Container Platform environments, all nodes are required to have internet access to pull images for platform containers and provide telemetry data to Red Hat.

Table 21.42. Ports used for all-machine to all-machine communications

Protocol	Port	Description
ICMP	N/A	Network reachability tests
TCP	**1936**	Metrics
	9000-**9999**	Host level services, including the node exporter on ports **9100**-**9101** and the Cluster Version Operator on port**9099**.
	10250-**10259**	The default ports that Kubernetes reserves
	10256	openshift-sdn
UDP	**4789**	VXLAN
	6081	Geneve
	9000-**9999**	Host level services, including the node exporter on ports **9100**-**9101**.
	500	IPsec IKE packets
	4500	IPsec NAT-T packets
TCP/UDP	**30000**-**32767**	Kubernetes node port
ESP	N/A	IPsec Encapsulating Security Payload (ESP)

Table 21.43. Ports used for all-machine to control plane communications

Protocol	Port	Description
TCP	**6443**	Kubernetes API

Table 21.44. Ports used for control plane machine to control plane machine communications

Protocol	Port	Description
TCP	**2379**-**2380**	etcd server and peer ports

Ethernet adaptor hardware address requirements
When provisioning VMs for the cluster, the ethernet interfaces configured for each VM must use a MAC address from the VMware Organizationally Unique Identifier (OUI) allocation ranges:

- **00:05:69:00:00:00** to **00:05:69:FF:FF:FF**

- **00:0c:29:00:00:00** to **00:0c:29:FF:FF:FF**
- **00:1c:14:00:00:00** to **00:1c:14:FF:FF:FF**
- **00:50:56:00:00:00** to **00:50:56:3F:FF:FF**

If a MAC address outside the VMware OUI is used, the cluster installation will not succeed.

NTP configuration for user-provisioned infrastructure
OpenShift Container Platform clusters are configured to use a public Network Time Protocol (NTP) server by default. If you want to use a local enterprise NTP server, or if your cluster is being deployed in a disconnected network, you can configure the cluster to use a specific time server. For more information, see the documentation for *Configuring chrony time service* .

If a DHCP server provides NTP server information, the chrony time service on the Red Hat Enterprise Linux CoreOS (RHCOS) machines read the information and can sync the clock with the NTP servers.

Additional resources

- Configuring chrony time service

21.5.5.5. User-provisioned DNS requirements

In OpenShift Container Platform deployments, DNS name resolution is required for the following components:

- The Kubernetes API
- The OpenShift Container Platform application wildcard
- The bootstrap, control plane, and compute machines

Reverse DNS resolution is also required for the Kubernetes API, the bootstrap machine, the control plane machines, and the compute machines.

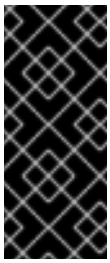
DNS A/AAAA or CNAME records are used for name resolution and PTR records are used for reverse name resolution. The reverse records are important because Red Hat Enterprise Linux CoreOS (RHCOS) uses the reverse records to set the hostnames for all the nodes, unless the hostnames are provided by DHCP. Additionally, the reverse records are used to generate the certificate signing requests (CSR) that OpenShift Container Platform needs to operate.

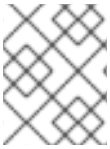
NOTE

It is recommended to use a DHCP server to provide the hostnames to each cluster node. See the *DHCP recommendations for user-provisioned infrastructure* section for more information.

The following DNS records are required for a user-provisioned OpenShift Container Platform cluster and they must be in place before installation. In each record, **<cluster_name>** is the cluster name and **<base_domain>** is the base domain that you specify in the **install-config.yaml** file. A complete DNS record takes the form: **<component>.<cluster_name>.<base_domain>.**.

Table 21.45. Required DNS records

Component	Record	Description
Kubernetes API	**api.<cluster_name>.<base_domain>.**	A DNS A/AAAA or CNAME record, and a DNS PTR record, to identify the API load balancer. These records must be resolvable by both clients external to the cluster and from all the nodes within the cluster.
	api-int.<cluster_name>.<base_domain>.	A DNS A/AAAA or CNAME record, and a DNS PTR record, to internally identify the API load balancer. These records must be resolvable from all the nodes within the cluster.  **IMPORTANT** The API server must be able to resolve the worker nodes by the hostnames that are recorded in Kubernetes. If the API server cannot resolve the node names, then proxied API calls can fail, and you cannot retrieve logs from pods.
Routes	***.apps.<cluster_name>.<base_domain>.**	A wildcard DNS A/AAAA or CNAME record that refers to the application ingress load balancer. The application ingress load balancer targets the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default. These records must be resolvable by both clients external to the cluster and from all the nodes within the cluster. For example, **console-openshift-console.apps.<cluster_name>.<base_domain>** is used as a wildcard route to the OpenShift Container Platform console.
Bootstrap machine	**bootstrap.<cluster_name>.<base_domain>.**	A DNS A/AAAA or CNAME record, and a DNS PTR record, to identify the bootstrap machine. These records must be resolvable by the nodes within the cluster.
Control plane machines	**<master><n>.<cluster_name>.<base_domain>.**	DNS A/AAAA or CNAME records and DNS PTR records to identify each machine for the control plane nodes. These records must be resolvable by the nodes within the cluster.
Compute machines	**<worker><n>.<cluster_name>.<base_domain>.**	DNS A/AAAA or CNAME records and DNS PTR records to identify each machine for the worker nodes. These records must be resolvable by the nodes within the cluster.



NOTE

In OpenShift Container Platform 4.4 and later, you do not need to specify etcd host and SRV records in your DNS configuration.

TIP

You can use the **dig** command to verify name and reverse name resolution. See the section on *Validating DNS resolution for user-provisioned infrastructure* for detailed validation steps.

21.5.5.5.1. Example DNS configuration for user-provisioned clusters

This section provides A and PTR record configuration samples that meet the DNS requirements for deploying OpenShift Container Platform on user-provisioned infrastructure. The samples are not meant to provide advice for choosing one DNS solution over another.

In the examples, the cluster name is **ocp4** and the base domain is **example.com**.

Example DNS A record configuration for a user-provisioned cluster

The following example is a BIND zone file that shows sample A records for name resolution in a user-provisioned cluster.

Example 21.10. Sample DNS zone database

```
$TTL 1W
@ IN SOA ns1.example.com. root (
  2019070700 ; serial
  3H  ; refresh (3 hours)
  30M  ; retry (30 minutes)
  2W  ; expiry (2 weeks)
  1W )  ; minimum (1 week)
 IN NS ns1.example.com.
 IN MX 10 smtp.example.com.
;
;
ns1.example.com.  IN A 192.168.1.5
smtp.example.com.  IN A 192.168.1.5
;
helper.example.com.  IN A 192.168.1.5
helper.ocp4.example.com. IN A 192.168.1.5
;
api.ocp4.example.com.  IN A 192.168.1.5 1
api-int.ocp4.example.com. IN A 192.168.1.5 2
;
*.apps.ocp4.example.com. IN A 192.168.1.5 3
;
bootstrap.ocp4.example.com. IN A 192.168.1.96 4
;
master0.ocp4.example.com. IN A 192.168.1.97 5
master1.ocp4.example.com. IN A 192.168.1.98 6
master2.ocp4.example.com. IN A 192.168.1.99 7
;
worker0.ocp4.example.com. IN A 192.168.1.11 8
worker1.ocp4.example.com. IN A 192.168.1.7 9
;
;EOF
```

1 Provides name resolution for the Kubernetes API. The record refers to the IP address of the API load balancer.

2 Provides name resolution for the Kubernetes API. The record refers to the IP address of the API load balancer and is used for internal cluster communications.

3 Provides name resolution for the wildcard routes. The record refers to the IP address of the application ingress load balancer. The application ingress load balancer targets the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.

NOTE

In the example, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

4 Provides name resolution for the bootstrap machine.

5 6 7 Provides name resolution for the control plane machines.

8 9 Provides name resolution for the compute machines.

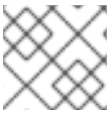
Example DNS PTR record configuration for a user-provisioned cluster

The following example BIND zone file shows sample PTR records for reverse name resolution in a user-provisioned cluster.

Example 21.11. Sample DNS zone database for reverse records

```
$TTL 1W
@ IN SOA ns1.example.com. root (
  2019070700 ; serial
  3H  ; refresh (3 hours)
  30M  ; retry (30 minutes)
  2W  ; expiry (2 weeks)
  1W )  ; minimum (1 week)
 IN NS ns1.example.com.
;
5.1.168.192.in-addr.arpa. IN PTR api.ocp4.example.com. 1
5.1.168.192.in-addr.arpa. IN PTR api-int.ocp4.example.com. 2
;
96.1.168.192.in-addr.arpa. IN PTR bootstrap.ocp4.example.com. 3
;
97.1.168.192.in-addr.arpa. IN PTR master0.ocp4.example.com. 4
98.1.168.192.in-addr.arpa. IN PTR master1.ocp4.example.com. 5
99.1.168.192.in-addr.arpa. IN PTR master2.ocp4.example.com. 6
;
11.1.168.192.in-addr.arpa. IN PTR worker0.ocp4.example.com. 7
7.1.168.192.in-addr.arpa. IN PTR worker1.ocp4.example.com. 8
;
;EOF
```

1. Provides reverse DNS resolution for the Kubernetes API. The PTR record refers to the record name of the API load balancer.
2. Provides reverse DNS resolution for the Kubernetes API. The PTR record refers to the record name of the API load balancer and is used for internal cluster communications.
3. Provides reverse DNS resolution for the bootstrap machine.
4 5 6. Provides reverse DNS resolution for the control plane machines.
7 8. Provides reverse DNS resolution for the compute machines.



NOTE

A PTR record is not required for the OpenShift Container Platform application wildcard.

21.5.5.6. Load balancing requirements for user-provisioned infrastructure

Before you install OpenShift Container Platform, you must provision the API and application ingress load balancing infrastructure. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

NOTE

If you want to deploy the API and application Ingress load balancers with a Red Hat Enterprise Linux (RHEL) instance, you must purchase the RHEL subscription separately.

The load balancing infrastructure must meet the following requirements:

1. **API load balancer**: Provides a common endpoint for users, both human and machine, to interact with and configure the platform. Configure the following conditions:
   - Layer 4 load balancing only. This can be referred to as Raw TCP, SSL Passthrough, or SSL Bridge mode. If you use SSL Bridge mode, you must enable Server Name Indication (SNI) for the API routes.
   - A stateless load balancing algorithm. The options vary based on the load balancer implementation.

IMPORTANT

Do not configure session persistence for an API load balancer. Configuring session persistence for a Kubernetes API server might cause performance issues from excess application traffic for your OpenShift Container Platform cluster and the Kubernetes API that runs inside the cluster.

Configure the following ports on both the front and back of the load balancers:

Table 21.46. API load balancer

Port	Back-end machines (pool members)	Internal	External	Description
6443	Bootstrap and control plane. You remove the bootstrap machine from the load balancer after the bootstrap machine initializes the cluster control plane. You must configure the **/readyz** endpoint for the API server health check probe.	X	X	Kubernetes API server
22623	Bootstrap and control plane. You remove the bootstrap machine from the load balancer after the bootstrap machine initializes the cluster control plane.	X		Machine config server

NOTE

The load balancer must be configured to take a maximum of 30 seconds from the time the API server turns off the **/readyz** endpoint to the removal of the API server instance from the pool. Within the time frame after **/readyz** returns an error or becomes healthy, the endpoint must have been removed or added. Probing every 5 or 10 seconds, with two successful requests to become healthy and three to become unhealthy, are well-tested values.

2. **Application Ingress load balancer**: Provides an ingress point for application traffic flowing in from outside the cluster. A working configuration for the Ingress router is required for an OpenShift Container Platform cluster.
Configure the following conditions:

   - Layer 4 load balancing only. This can be referred to as Raw TCP, SSL Passthrough, or SSL Bridge mode. If you use SSL Bridge mode, you must enable Server Name Indication (SNI) for the ingress routes.
   - A connection-based or session-based persistence is recommended, based on the options available and types of applications that will be hosted on the platform.

TIP

If the true IP address of the client can be seen by the application Ingress load balancer, enabling source IP-based session persistence can improve performance for applications that use end-to-end TLS encryption.

Configure the following ports on both the front and back of the load balancers:

Table 21.47. Application Ingress load balancer

Port	Back-end machines (pool members)	Internal	External	Description

Port	Back-end machines (pool members)	Internal	External	Description
443	The machines that run the Ingress Controller pods, compute, or worker, by default.	X	X	HTTPS traffic
80	The machines that run the Ingress Controller pods, compute, or worker, by default.	X	X	HTTP traffic

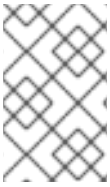
NOTE

If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application Ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes.

21.5.5.6.1. Example load balancer configuration for user-provisioned clusters

This section provides an example API and application ingress load balancer configuration that meets the load balancing requirements for user-provisioned clusters. The sample is an **/etc/haproxy/haproxy.cfg** configuration for an HAProxy load balancer. The example is not meant to provide advice for choosing one load balancing solution over another.

In the example, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.



NOTE

If you are using HAProxy as a load balancer and SELinux is set to **enforcing**, you must ensure that the HAProxy service can bind to the configured TCP port by running **setsebool -P haproxy_connect_any=1**.

Example 21.12. Sample API and application Ingress load balancer configuration

```
global
  log         127.0.0.1 local2
  pidfile     /var/run/haproxy.pid
  maxconn     4000
  daemon
defaults
  mode                    http
  log                     global
  option                  dontlognull
  option http-server-close
  option                  redispatch
  retries                 3
  timeout http-request    10s
  timeout queue           1m
  timeout connect         10s
  timeout client          1m
```

```
  timeout server          1m
  timeout http-keep-alive 10s
  timeout check           10s
  maxconn                 3000
listen api-server-6443 (1)
  bind *:6443
  mode tcp
  server bootstrap bootstrap.ocp4.example.com:6443 check inter 1s backup (2)
  server master0 master0.ocp4.example.com:6443 check inter 1s
  server master1 master1.ocp4.example.com:6443 check inter 1s
  server master2 master2.ocp4.example.com:6443 check inter 1s
listen machine-config-server-22623 (3)
  bind *:22623
  mode tcp
  option  httpchk GET /readyz HTTP/1.0
  option  log-health-checks
  balance roundrobin
  server bootstrap bootstrap.ocp4.example.com:6443 verify none check check-ssl inter 10s fall 2
rise 3 backup (4)
  server master0 master0.ocp4.example.com:6443 weight 1 verify none check check-ssl inter 10s
fall 2 rise 3
  server master1 master1.ocp4.example.com:6443 weight 1 verify none check check-ssl inter 10s
fall 2 rise 3
  server master2 master2.ocp4.example.com:6443 weight 1 verify none check check-ssl inter 10s
fall 2 rise 3
listen ingress-router-443 (5)
  bind *:443
  mode tcp
  balance source
  server worker0 worker0.ocp4.example.com:443 check inter 1s
  server worker1 worker1.ocp4.example.com:443 check inter 1s
listen ingress-router-80 (6)
  bind *:80
  mode tcp
  balance source
  server worker0 worker0.ocp4.example.com:80 check inter 1s
  server worker1 worker1.ocp4.example.com:80 check inter 1s
```

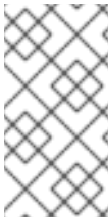
(1) Port **6443** handles the Kubernetes API traffic and points to the control plane machines.

(2) (4) The bootstrap entries must be in place before the OpenShift Container Platform cluster installation and they must be removed after the bootstrap process is complete.

(3) Port **22623** handles the machine config server traffic and points to the control plane machines.

(5) Port **443** handles the HTTPS traffic and points to the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.

(6) Port **80** handles the HTTP traffic and points to the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.



NOTE

If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application Ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes.

TIP

If you are using HAProxy as a load balancer, you can check that the **haproxy** process is listening on ports **6443**, **22623**, **443**, and **80** by running **netstat -nltupe** on the HAProxy node.

21.5.6. Preparing the user-provisioned infrastructure

Before you install OpenShift Container Platform on user-provisioned infrastructure, you must prepare the underlying infrastructure.

This section provides details about the high-level steps required to set up your cluster infrastructure in preparation for an OpenShift Container Platform installation. This includes configuring IP networking and network connectivity for your cluster nodes, enabling the required ports through your firewall, and setting up the required DNS and load balancing infrastructure.

After preparation, your cluster infrastructure must meet the requirements outlined in the *Requirements for a cluster with user-provisioned infrastructure* section.

Prerequisites

- You have reviewed the OpenShift Container Platform 4.x Tested Integrations page.
- You have reviewed the infrastructure requirements detailed in the *Requirements for a cluster with user-provisioned infrastructure* section.

Procedure

1. If you are using DHCP to provide the IP networking configuration to your cluster nodes, configure your DHCP service.
   a. Add persistent IP addresses for the nodes to your DHCP server configuration. In your configuration, match the MAC address of the relevant network interface to the intended IP address for each node.
   b. When you use DHCP to configure IP addressing for the cluster machines, the machines also obtain the DNS server information through DHCP. Define the persistent DNS server address that is used by the cluster nodes through your DHCP server configuration.

NOTE

If you are not using a DHCP service, you must provide the IP networking configuration and the address of the DNS server to the nodes at RHCOS install time. These can be passed as boot arguments if you are installing from an ISO image. See the *Installing RHCOS and starting the OpenShift Container Platform bootstrap process* section for more information about static IP provisioning and advanced networking options.

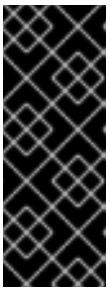
c. Define the hostnames of your cluster nodes in your DHCP server configuration. See the *Setting the cluster node hostnames through DHCP* section for details about hostname considerations.

NOTE

If you are not using a DHCP service, the cluster nodes obtain their hostname through a reverse DNS lookup.

2. Ensure that your network infrastructure provides the required network connectivity between the cluster components. See the *Networking requirements for user-provisioned infrastructure* section for details about the requirements.

3. Configure your firewall to enable the ports required for the OpenShift Container Platform cluster components to communicate. See *Networking requirements for user-provisioned infrastructure* section for details about the ports that are required.



IMPORTANT

By default, port **1936** is accessible for an OpenShift Container Platform cluster, because each control plane node needs access to this port.

Avoid using the Ingress load balancer to expose this port, because doing so might result in the exposure of sensitive information, such as statistics and metrics, related to Ingress Controllers.

4. Setup the required DNS infrastructure for your cluster.

   a. Configure DNS name resolution for the Kubernetes API, the application wildcard, the bootstrap machine, the control plane machines, and the compute machines.

   b. Configure reverse DNS resolution for the Kubernetes API, the bootstrap machine, the control plane machines, and the compute machines.
   See the *User-provisioned DNS requirements* section for more information about the OpenShift Container Platform DNS requirements.

5. Validate your DNS configuration.

   a. From your installation node, run DNS lookups against the record names of the Kubernetes API, the wildcard routes, and the cluster nodes. Validate that the IP addresses in the responses correspond to the correct components.

   b. From your installation node, run reverse DNS lookups against the IP addresses of the load balancer and the cluster nodes. Validate that the record names in the responses correspond to the correct components.
   See the *Validating DNS resolution for user-provisioned infrastructure* section for detailed DNS validation steps.

6. Provision the required API and application ingress load balancing infrastructure. See the *Load balancing requirements for user-provisioned infrastructure* section for more information about the requirements.

NOTE

Some load balancing solutions require the DNS name resolution for the cluster nodes to be in place before the load balancing is initialized.

21.5.7. Validating DNS resolution for user-provisioned infrastructure

You can validate your DNS configuration before installing OpenShift Container Platform on user-provisioned infrastructure.

IMPORTANT

The validation steps detailed in this section must succeed before you install your cluster.

Prerequisites

- You have configured the required DNS records for your user-provisioned infrastructure.

Procedure

1. From your installation node, run DNS lookups against the record names of the Kubernetes API, the wildcard routes, and the cluster nodes. Validate that the IP addresses contained in the responses correspond to the correct components.

   a. Perform a lookup against the Kubernetes API record name. Check that the result points to the IP address of the API load balancer:

   ```
   $ dig +noall +answer @<nameserver_ip> api.<cluster_name>.<base_domain>
   ```
   (1)

   (1) Replace **<nameserver_ip>** with the IP address of the nameserver, **<cluster_name>** with your cluster name, and **<base_domain>** with your base domain name.

   Example output

   ```
   api.ocp4.example.com.  604800 IN A 192.168.1.5
   ```

   b. Perform a lookup against the Kubernetes internal API record name. Check that the result points to the IP address of the API load balancer:

   ```
   $ dig +noall +answer @<nameserver_ip> api-int.<cluster_name>.<base_domain>
   ```

   Example output

   ```
   api-int.ocp4.example.com.  604800 IN A 192.168.1.5
   ```

   c. Test an example ***.apps.<cluster_name>.<base_domain>** DNS wildcard lookup. All of the application wildcard lookups must resolve to the IP address of the application ingress load balancer:

   ```
   $ dig +noall +answer @<nameserver_ip> random.apps.<cluster_name>.<base_domain>
   ```

   Example output

```
random.apps.ocp4.example.com.  604800 IN A 192.168.1.5
```

NOTE

In the example outputs, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

You can replace **random** with another wildcard value. For example, you can query the route to the OpenShift Container Platform console:

```
$ dig +noall +answer @<nameserver_ip> console-openshift-console.apps.
<cluster_name>.<base_domain>
```

Example output

```
console-openshift-console.apps.ocp4.example.com. 604800 IN A 192.168.1.5
```

d. Run a lookup against the bootstrap DNS record name. Check that the result points to the IP address of the bootstrap node:

```
$ dig +noall +answer @<nameserver_ip> bootstrap.<cluster_name>.<base_domain>
```

Example output

```
bootstrap.ocp4.example.com.  604800 IN A 192.168.1.96
```

e. Use this method to perform lookups against the DNS record names for the control plane and compute nodes. Check that the results correspond to the IP addresses of each node.

2. From your installation node, run reverse DNS lookups against the IP addresses of the load balancer and the cluster nodes. Validate that the record names contained in the responses correspond to the correct components.

a. Perform a reverse lookup against the IP address of the API load balancer. Check that the response includes the record names for the Kubernetes API and the Kubernetes internal API:

```
$ dig +noall +answer @<nameserver_ip> -x 192.168.1.5
```

Example output

```
5.1.168.192.in-addr.arpa. 604800 IN PTR api-int.ocp4.example.com. 1
5.1.168.192.in-addr.arpa. 604800 IN PTR api.ocp4.example.com. 2
```

1 Provides the record name for the Kubernetes internal API.

2 Provides the record name for the Kubernetes API.

NOTE

A PTR record is not required for the OpenShift Container Platform application wildcard. No validation step is needed for reverse DNS resolution against the IP address of the application ingress load balancer.

b. Perform a reverse lookup against the IP address of the bootstrap node. Check that the result points to the DNS record name of the bootstrap node:

```
$ dig +noall +answer @<nameserver_ip> -x 192.168.1.96
```

Example output

```
96.1.168.192.in-addr.arpa. 604800 IN PTR bootstrap.ocp4.example.com.
```

c. Use this method to perform reverse lookups against the IP addresses for the control plane and compute nodes. Check that the results correspond to the DNS record names of each node.

21.5.8. Generating a key pair for cluster node SSH access

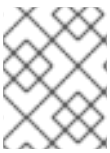
During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the **~/.ssh/authorized_keys** list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The **./openshift-install gather** command also requires the SSH public key to be in place on the cluster nodes.

IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.



NOTE

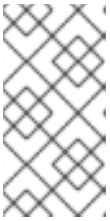
You must use a local key, not one that you configured with platform-specific approaches such as AWS key pairs.

Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N '' -f <path>/<file_name>
```
(1)

1 Specify the path and file name, such as ~/**.ssh/id_ed25519**, of the new SSH key. If you have an existing key pair, ensure your public key is in the your ~/**.ssh** directory.



NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS validated or Modules In Process cryptographic libraries on the **x86_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

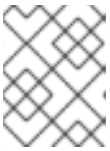
2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the ~/**.ssh/id_ed25519.pub** public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the **./openshift-install gather** command.



NOTE

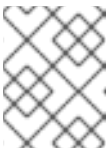
On some distributions, default SSH private key identities such as ~/**.ssh/id_rsa** and ~/**.ssh/id_dsa** are managed automatically.

a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

Example output

```
Agent pid 31874
```



NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

1 Specify the path and file name for your SSH private key, such as ~/**.ssh/id_ed25519**

Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program. If you install a cluster on infrastructure that you provision, you must provide the key to the installation program.

21.5.9. Obtaining the installation program

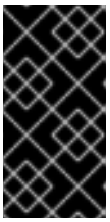
Before you install OpenShift Container Platform, download the installation file on a local computer.

Prerequisites

- You have a computer that runs Linux or macOS, with 500 MB of local disk space.

Procedure

1. Access the Infrastructure Provider page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program that corresponds with your host operating system and architecture, and place the file in the directory where you will store the installation configuration files.



IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.

IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation pull secret from the Red Hat OpenShift Cluster Manager . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

21.5.10. Manually creating the installation configuration file

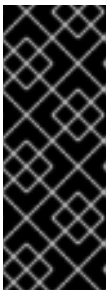
Prerequisites

- You have an SSH public key on your local machine to provide to the installation program. The key will be used for SSH authentication onto your cluster nodes for debugging and disaster recovery.
- You have obtained the OpenShift Container Platform installation program and the pull secret for your cluster.

Procedure

1. Create an installation directory to store your required installation assets in:

```
$ mkdir <installation_directory>
```



IMPORTANT

You must create a directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

2. Customize the sample **install-config.yaml** file template that is provided and save it in the **<installation_directory>**.

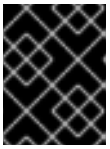
NOTE

You must name this configuration file **install-config.yaml**.

NOTE

For some platform types, you can alternatively run **./openshift-install create install-config --dir <installation_directory>** to generate an **install-config.yaml** file. You can provide details about your cluster configuration at the prompts.

3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.



IMPORTANT

The **install-config.yaml** file is consumed during the next step of the installation process. You must back it up now.

21.5.10.1. Sample install-config.yaml file for VMware vSphere

You can customize the **install-config.yaml** file to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.

```
apiVersion: v1
baseDomain: example.com 1
compute: 2
```

```
  name: worker
  replicas: 0 3
controlPlane: 4
  name: master
  replicas: 3 5
metadata:
  name: test 6
platform:
  vsphere:
    vcenter: your.vcenter.server 7
    username: username 8
    password: password 9
    datacenter: datacenter 10
    defaultDatastore: datastore 11
    folder: "/<datacenter_name>/vm/<folder_name>/<subfolder_name>" 12
    resourcePool: "/<datacenter_name>/host/<cluster_name>/Resources/<resource_pool_name>" 13
    diskType: thin 14
fips: false 15
pullSecret: '{"auths": ...}' 16
sshKey: 'ssh-ed25519 AAAA...' 17
```

1. The base domain of the cluster. All DNS records must be sub-domains of this base and include the cluster name.

2 4. The **controlPlane** section is a single mapping, but the compute section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, (**-**), and the first line of the **controlPlane** section must not. Although both sections currently define a single machine pool, it is possible that future versions of OpenShift Container Platform will support defining multiple compute pools during installation. Only one control plane pool is used.

3. You must set the value of the **replicas** parameter to **0**. This parameter controls the number of workers that the cluster creates and manages for you, which are functions that the cluster does not perform when you use user-provisioned infrastructure. You must manually deploy worker machines for the cluster to use before you finish installing OpenShift Container Platform.

5. The number of control plane machines that you add to the cluster. Because the cluster uses this values as the number of etcd endpoints in the cluster, the value must match the number of control plane machines that you deploy.

6. The cluster name that you specified in your DNS records.

7. The fully-qualified hostname or IP address of the vCenter server.

IMPORTANT

The Cluster Cloud Controller Manager Operator performs a connectivity check on a provided hostname or IP address. Ensure that you specify a hostname or an IP address to a reachable vCenter server. If you provide metadata to a non-existent vCenter server, installation of the cluster fails at the bootstrap stage.

8. The name of the user for accessing the server.

9. The password associated with the vSphere user.
10. The vSphere datacenter.
11. The default vSphere datastore to use.
12. Optional parameter: For installer-provisioned infrastructure, the absolute path of an existing folder where the installation program creates the virtual machines, for example, **/<datacenter_name>/vm/<folder_name>/<subfolder_name>**. If you do not provide this value, the installation program creates a top-level folder in the datacenter virtual machine folder that is named with the infrastructure ID. If you are providing the infrastructure for the cluster and you do not want to use the default **StorageClass** object, named **thin**, you can omit the **folder** parameter from the **install-config.yaml** file.
13. Optional parameter: For installer-provisioned infrastructure, the absolute path of an existing folder where the installation program creates the virtual machines, for example, **/<datacenter_name>/vm/<folder_name>/<subfolder_name>**. If you do not provide this value, the installation program creates a top-level folder in the datacenter virtual machine folder that is named with the infrastructure ID. If you are providing the infrastructure for the cluster, omit this parameter.
14. The vSphere disk provisioning method.
15. Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.

IMPORTANT

To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.

16. The pull secret that you obtained from OpenShift Cluster Manager Hybrid Cloud Console . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.
17. The public portion of the default SSH key for the **core** user in Red Hat Enterprise Linux CoreOS (RHCOS).

21.5.10.2. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

Prerequisites

- You have an existing **install-config.yaml** file.

- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.

NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
```

1. A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
2. A proxy URL to use for creating HTTPS connections outside the cluster.
3. A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use ***** to bypass the proxy for all destinations. You must include vCenter's IP address and the IP range that you use for its machines.
4. If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace that contains one or more additional CA certificates that are required for proxying HTTPS connections. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges these contents with the Red Hat Enterprise Linux CoreOS (RHCOS) trust bundle, and this config map is referenced in the **trustedCA** field of the **Proxy** object. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.

NOTE

The installation program does not support the proxy **readinessEndpoints** field.

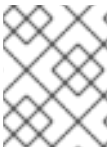
NOTE

If the installer times out, restart and then complete the deployment by using the **wait-for** command of the installer. For example:

```
$ ./openshift-install wait-for install-complete --log-level debug
```

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.



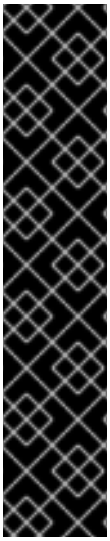
NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

21.5.11. Creating the Kubernetes manifest and Ignition config files

Because you must modify some cluster definition files and manually start the cluster machines, you must generate the Kubernetes manifest and Ignition config files that the cluster needs to configure the machines.

The installation configuration file transforms into the Kubernetes manifests. The manifests wrap into the Ignition configuration files, which are later used to configure the cluster machines.



IMPORTANT

- The Ignition config files that the OpenShift Container Platform installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

Prerequisites

- You obtained the OpenShift Container Platform installation program.
- You created the **install-config.yaml** installation configuration file.

Procedure

1. Change to the directory that contains the OpenShift Container Platform installation program and generate the Kubernetes manifests for the cluster:

```
$ ./openshift-install create manifests --dir <installation_directory> 1
```

1 For **<installation_directory>**, specify the installation directory that contains the **install-config.yaml** file you created.

2. Remove the Kubernetes manifest files that define the control plane machines and compute machine sets:

```
$ rm -f openshift/99_openshift-cluster-api_master-machines-*.yaml openshift/99_openshift-cluster-api_worker-machineset-*.yaml
```

Because you create and manage these resources yourself, you do not have to initialize them.

- You can preserve the machine set files to create compute machines by using the machine API, but you must update references to them to match your environment.

3. Check that the **mastersSchedulable** parameter in the **<installation_directory>/manifests/cluster-scheduler-02-config.yml** Kubernetes manifest file is set to **false**. This setting prevents pods from being scheduled on the control plane machines:

   a. Open the **<installation_directory>/manifests/cluster-scheduler-02-config.yml** file.

   b. Locate the **mastersSchedulable** parameter and ensure that it is set to **false**.

   c. Save and exit the file.

4. To create the Ignition configuration files, run the following command from the directory that contains the installation program:

```
$ ./openshift-install create ignition-configs --dir <installation_directory> 1
```

1 For **<installation_directory>**, specify the same installation directory.

Ignition config files are created for the bootstrap, control plane, and compute nodes in the installation directory. The **kubeadmin-password** and **kubeconfig** files are created in the **./<installation_directory>/auth** directory:

```
.
├── auth
│   ├── kubeadmin-password
│   └── kubeconfig
├── bootstrap.ign
├── master.ign
├── metadata.json
└── worker.ign
```

21.5.12. Extracting the infrastructure name

The Ignition config files contain a unique cluster identifier that you can use to uniquely identify your cluster in VMware vSphere. If you plan to use the cluster identifier as the name of your virtual machine folder, you must extract it.

Prerequisites

- You obtained the OpenShift Container Platform installation program and the pull secret for your cluster.
- You generated the Ignition config files for your cluster.
- You installed the **jq** package.

Procedure

- To extract and view the infrastructure name from the Ignition config file metadata, run the following command:

```
$ jq -r .infraID <installation_directory>/metadata.json 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

Example output

```
openshift-vw9j6 1
```

1 The output of this command is your cluster name and a random string.

21.5.13. Installing RHCOS and starting the OpenShift Container Platform bootstrap process

To install OpenShift Container Platform on user-provisioned infrastructure on VMware vSphere, you must install Red Hat Enterprise Linux CoreOS (RHCOS) on vSphere hosts. When you install RHCOS, you must provide the Ignition config file that was generated by the OpenShift Container Platform installation program for the type of machine you are installing. If you have configured suitable networking, DNS, and load balancing infrastructure, the OpenShift Container Platform bootstrap process begins automatically after the RHCOS machines have rebooted.

Prerequisites

- You have obtained the Ignition config files for your cluster.
- You have access to an HTTP server that you can access from your computer and that the machines that you create can access.
- You have created a vSphere cluster.

Procedure

1. Upload the bootstrap Ignition config file, which is named **<installation_directory>/bootstrap.ign**, that the installation program created to your HTTP server. Note the URL of this file.
2. Save the following secondary Ignition config file for your bootstrap node to your computer as **<installation_directory>/merge-bootstrap.ign**:

```
{
  "ignition": {
    "config": {
      "merge": [
        {
          "source": "<bootstrap_ignition_config_url>", 1
          "verification": {}
        }
      ]
    },
    "timeouts": {},
    "version": "3.2.0"
  },
  "networkd": {},
  "passwd": {},
  "storage": {},
  "systemd": {}
}
```

1 Specify the URL of the bootstrap Ignition config file that you hosted.

When you create the virtual machine (VM) for the bootstrap machine, you use this Ignition config file.

3. Locate the following Ignition config files that the installation program created:

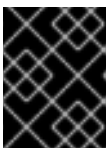
   - **<installation_directory>/master.ign**
   - **<installation_directory>/worker.ign**
   - **<installation_directory>/merge-bootstrap.ign**

4. Convert the Ignition config files to Base64 encoding. Later in this procedure, you must add these files to the extra configuration parameter **guestinfo.ignition.config.data** in your VM. For example, if you use a Linux operating system, you can use the **base64** command to encode the files.

```
$ base64 -w0 <installation_directory>/master.ign > <installation_directory>/master.64
```

```
$ base64 -w0 <installation_directory>/worker.ign > <installation_directory>/worker.64
```

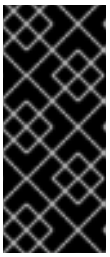
```
$ base64 -w0 <installation_directory>/merge-bootstrap.ign > <installation_directory>/merge-bootstrap.64
```



IMPORTANT

If you plan to add more compute machines to your cluster after you finish installation, do not delete these files.

5. Obtain the RHCOS OVA image. Images are available from the RHCOS image mirror page.



IMPORTANT

The RHCOS images might not change with every release of OpenShift Container Platform. You must download an image with the highest version that is less than or equal to the OpenShift Container Platform version that you install. Use the image version that matches your OpenShift Container Platform version if it is available.

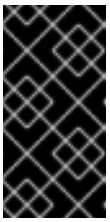
The filename contains the OpenShift Container Platform version number in the format **rhcos-vmware.<architecture>.ova**.

6. In the vSphere Client, create a folder in your datacenter to store your VMs.
   a. Click the **VMs and Templates** view.
   b. Right-click the name of your datacenter.
   c. Click **New Folder → New VM and Template Folder**.
   d. In the window that is displayed, enter the folder name. If you did not specify an existing folder in the **install-config.yaml** file, then create a folder with the same name as the infrastructure ID. You use this folder name so vCenter dynamically provisions storage in the appropriate location for its Workspace configuration.
7. In the vSphere Client, create a template for the OVA image and then clone the template as needed.

NOTE

In the following steps, you create a template and then clone the template for all of your cluster machines. You then provide the location for the Ignition config file for that cloned machine type when you provision the VMs.

   a. From the **Hosts and Clusters** tab, right-click your cluster name and select **Deploy OVF Template**.
   b. On the **Select an OVF** tab, specify the name of the RHCOS OVA file that you downloaded.
   c. On the **Select a name and folder** tab, set a **Virtual machine name** for your template, such as **Template-RHCOS**. Click the name of your vSphere cluster and select the folder you created in the previous step.
   d. On the **Select a compute resource** tab, click the name of your vSphere cluster.
   e. On the **Select storage** tab, configure the storage options for your VM.
      - Select **Thin Provision** or **Thick Provision**, based on your storage preferences.
      - Select the datastore that you specified in your **install-config.yaml** file.
   f. On the **Select network** tab, specify the network that you configured for the cluster, if available.
   g. When creating the OVF template, do not specify values on the **Customize template** tab or configure the template any further.



IMPORTANT

Do not start the original VM template. The VM template must remain off and must be cloned for new RHCOS machines. Starting the VM template configures the VM template as a VM on the platform, which prevents it from being used as a template that machine sets can apply configurations to.

8. Optional: Update the configured virtual hardware version in the VM template, if necessary. Follow Upgrading a virtual machine to the latest hardware version in the VMware documentation for more information.

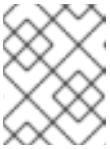
IMPORTANT

It is recommended that you update the hardware version of the VM template to version 15 before creating VMs from it, if necessary. Using hardware version 13 for your cluster nodes running on vSphere is now deprecated. If your imported template defaults to hardware version 13, you must ensure that your ESXi host is on 6.7U3 or later before upgrading the VM template to hardware version 15. If your vSphere version is less than 6.7U3, you can skip this upgrade step; however, a future version of OpenShift Container Platform is scheduled to remove support for hardware version 13 and vSphere versions less than 6.7U3.

9. After the template deploys, deploy a VM for a machine in the cluster.

   a. Right-click the template name and click **Clone → Clone to Virtual Machine**

   b. On the **Select a name and folder** tab, specify a name for the VM. You might include the machine type in the name, such as **control-plane-0** or **compute-1**.



NOTE

Ensure that all virtual machine names across a vSphere installation are unique.

   c. On the **Select a name and folder** tab, select the name of the folder that you created for the cluster.

   d. On the **Select a compute resource** tab, select the name of a host in your datacenter.

   e. On the **Select clone options**, select **Customize this virtual machine's hardware**.

   f. Optional: On the **Customize hardware** tab, click **VM Options → Advanced**.

IMPORTANT

The following configuration suggestions are for example purposes only. As a cluster administrator, you must configure resources according to the resource demands placed on your cluster. To best manage cluster resources, consider creating a resource pool from the cluster's root resource pool.

- Override default DHCP networking in vSphere. To enable static IP networking:
  - Set your static IP configuration:

```
$ export IPCFG="ip=<ip>::<gateway>:<netmask>:<hostname>:<iface>:none
nameserver=srv1 [nameserver=srv2 [nameserver=srv3 [...]]]"
```

Example command

```
$ export IPCFG="ip=192.168.100.101::192.168.100.254:255.255.255.0:::none
nameserver=8.8.8.8"
```

- Click **Edit Configuration**, and on the **Configuration Parameters** window, search the list of available parameters for steal clock accounting (**stealclock.enable**). Set the parameter to the value of **TRUE**. Enabling steal clock accounting can help with troubleshooting cluster issues.
- Click **Add Configuration Params**. Define the following parameter names and values:
  - **disk.EnableUUID**: Specify **TRUE**.
  - **stealclock.enable**: If this parameter was not defined, add it and specify **TRUE**.
  - Create a child resource pool from the cluster's root resource pool. Perform resource allocation in this child resource pool.

g. In the **Virtual Hardware** panel of the **Customize hardware** tab, modify the specified values as required. Ensure that the amount of RAM, CPU, and disk storage meets the minimum requirements for the machine type.

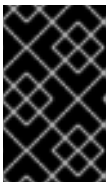
h. Complete the configuration and power on the VM.

i. Check the console output to verify that Ignition ran.

Example command

```
Ignition: ran on 2022/03/14 14:48:33 UTC (this boot)
Ignition: user-provided config was applied
```

10. Create the rest of the machines for your cluster by following the preceding steps for each machine.



IMPORTANT

You must create the bootstrap and control plane machines at this time. Because some pods are deployed on compute machines by default, also create at least two compute machines before you install the cluster.

21.5.14. Adding more compute machines to a cluster in vSphere

You can add more compute machines to a user-provisioned OpenShift Container Platform cluster on VMware vSphere.

Prerequisites

- Obtain the base64-encoded Ignition file for your compute machines.
- You have access to the vSphere template that you created for your cluster.

Procedure

1. After the template deploys, deploy a VM for a machine in the cluster.
   a. Right-click the template's name and click **Clone → Clone to Virtual Machine**
   b. On the **Select a name and folder** tab, specify a name for the VM. You might include the machine type in the name, such as **compute-1**.

      NOTE

      Ensure that all virtual machine names across a vSphere installation are unique.

   c. On the **Select a name and folder** tab, select the name of the folder that you created for the cluster.
   d. On the **Select a compute resource** tab, select the name of a host in your datacenter.
   e. On the **Select clone options**, select **Customize this virtual machine's hardware**.
   f. On the **Customize hardware** tab, click **VM Options → Advanced**.
      - Click **Edit Configuration**, and on the **Configuration Parameters** window, click **Add Configuration Params**. Define the following parameter names and values:
        - **guestinfo.ignition.config.data**: Paste the contents of the base64-encoded compute Ignition config file for this machine type.
        - **guestinfo.ignition.config.data.encoding**: Specify **base64**.
        - **disk.EnableUUID**: Specify **TRUE**.
   g. In the **Virtual Hardware** panel of the **Customize hardware** tab, modify the specified values as required. Ensure that the amount of RAM, CPU, and disk storage meets the minimum requirements for the machine type. Also, make sure to select the correct network under **Add network adapter** if there are multiple networks available.
   h. Complete the configuration and power on the VM.
2. Continue to create more compute machines for your cluster.

21.5.15. Disk partitioning

In most cases, data partitions are originally created by installing RHCOS, rather than by installing another operating system. In such cases, the OpenShift Container Platform installer should be allowed to configure your disk partitions.

However, there are two cases where you might want to intervene to override the default partitioning when installing an OpenShift Container Platform node:

- Create separate partitions: For greenfield installations on an empty disk, you might want to add separate storage to a partition. This is officially supported for making **/var** or a subdirectory of **/var**, such as **/var/lib/etcd**, a separate partition, but not both.

IMPORTANT

For disk sizes larger than 100GB, and especially disk sizes larger than 1TB, create a separate **/var** partition. See "Creating a separate **/var** partition" and this Red Hat Knowledgebase article for more information.

IMPORTANT

Kubernetes supports only two file system partitions. If you add more than one partition to the original configuration, Kubernetes cannot monitor all of them.

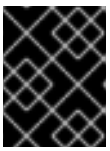
- Retain existing partitions: For a brownfield installation where you are reinstalling OpenShift Container Platform on an existing node and want to retain data partitions installed from your previous operating system, there are both boot arguments and options to **coreos-installer** that allow you to retain existing data partitions.

Creating a separate /var partition

In general, disk partitioning for OpenShift Container Platform should be left to the installer. However, there are cases where you might want to create separate partitions in a part of the filesystem that you expect to grow.

OpenShift Container Platform supports the addition of a single partition to attach storage to either the **/var** partition or a subdirectory of **/var**. For example:

- **/var/lib/containers**: Holds container-related content that can grow as more images and containers are added to a system.
- **/var/lib/etcd**: Holds data that you might want to keep separate for purposes such as performance optimization of etcd storage.
- **/var**: Holds data that you might want to keep separate for purposes such as auditing.



IMPORTANT

For disk sizes larger than 100GB, and especially larger than 1TB, create a separate **/var** partition.

Storing the contents of a **/var** directory separately makes it easier to grow storage for those areas as needed and reinstall OpenShift Container Platform at a later date and keep that data intact. With this method, you will not have to pull all your containers again, nor will you have to copy massive log files when you update systems.

Because **/var** must be in place before a fresh installation of Red Hat Enterprise Linux CoreOS (RHCOS), the following procedure sets up the separate **/var** partition by creating a machine config manifest that is inserted during the **openshift-install** preparation phases of an OpenShift Container Platform installation.

Procedure

1. Create a directory to hold the OpenShift Container Platform installation files:

```
$ mkdir $HOME/clusterconfig
```

2. Run **openshift-install** to create a set of files in the **manifest** and **openshift** subdirectories. Answer the system questions as you are prompted:

```
$ openshift-install create manifests --dir $HOME/clusterconfig
? SSH Public Key ...
$ ls $HOME/clusterconfig/openshift/
99_kubeadmin-password-secret.yaml
99_openshift-cluster-api_master-machines-0.yaml
99_openshift-cluster-api_master-machines-1.yaml
99_openshift-cluster-api_master-machines-2.yaml
...
```

3. Create a Butane config that configures the additional partition. For example, name the file **$HOME/clusterconfig/98-var-partition.bu**, change the disk device name to the name of the storage device on the **worker** systems, and set the storage size as appropriate. This example places the **/var** directory on a separate partition:

```
variant: openshift
version: 4.11.0
metadata:
  labels:
    machineconfiguration.openshift.io/role: worker
  name: 98-var-partition
storage:
  disks:
  - device: /dev/<device_name> 1
    partitions:
    - label: var
      start_mib: <partition_start_offset> 2
      size_mib: <partition_size> 3
  filesystems:
    - device: /dev/disk/by-partlabel/var
      path: /var
      format: xfs
      mount_options: [defaults, prjquota] 4
      with_mount_unit: true
```

1. The storage device name of the disk that you want to partition.
2. When adding a data partition to the boot disk, a minimum value of 25000 mebibytes is recommended. The root file system is automatically resized to fill all available space up to the specified offset. If no value is specified, or if the specified value is smaller than the recommended minimum, the resulting root file system will be too small, and future reinstalls of RHCOS might overwrite the beginning of the data partition.
3. The size of the data partition in mebibytes.
4. The **prjquota** mount option must be enabled for filesystems used for container storage.

NOTE

When creating a separate **/var** partition, you cannot use different instance types for worker nodes, if the different instance types do not have the same device name.

4. Create a manifest from the Butane config and save it to the **clusterconfig/openshift** directory. For example, run the following command:

```
$ butane $HOME/clusterconfig/98-var-partition.bu -o $HOME/clusterconfig/openshift/98-var-partition.yaml
```

5. Run **openshift-install** again to create Ignition configs from a set of files in the **manifest** and **openshift** subdirectories:

```
$ openshift-install create ignition-configs --dir $HOME/clusterconfig
$ ls $HOME/clusterconfig/
auth  bootstrap.ign  master.ign  metadata.json  worker.ign
```

Now you can use the Ignition config files as input to the vSphere installation procedures to install Red Hat Enterprise Linux CoreOS (RHCOS) systems.

21.5.16. Updating the bootloader using bootupd

To update the bootloader by using **bootupd**, you must either install **bootupd** on RHCOS machines manually or provide a machine config with the enabled **systemd** unit. Unlike **grubby** or other bootloader tools, **bootupd** does not manage kernel space configuration such as passing kernel arguments.

After you have installed **bootupd**, you can manage it remotely from the OpenShift Container Platform cluster.

NOTE

It is recommended that you use **bootupd** only on bare metal or virtualized hypervisor installations, such as for protection against the BootHole vulnerability.

Manual install method

You can manually install **bootupd** by using the **bootctl** command-line tool.

1. Inspect the system status:

```
# bootupctl status
```

Example output for x86_64

```
Component EFI
  Installed: grub2-efi-x64-1:2.04-31.fc33.x86_64,shim-x64-15-8.x86_64
  Update: At latest version
```

Example output for aarch64

```
Component EFI
  Installed: grub2-efi-aa64-1:2.02-99.el8_4.1.aarch64,shim-aa64-15.4-2.el8_1.aarch64
  Update: At latest version
```

2. RHCOS images created without **bootupd** installed on them require an explicit adoption phase. If the system status is **Adoptable**, perform the adoption:

```
# bootupctl adopt-and-update
```

Example output

```
Updated: grub2-efi-x64-1:2.04-31.fc33.x86_64,shim-x64-15-8.x86_64
```

3. If an update is available, apply the update so that the changes take effect on the next reboot:

```
# bootupctl update
```

Example output

```
Updated: grub2-efi-x64-1:2.04-31.fc33.x86_64,shim-x64-15-8.x86_64
```

Machine config method

Another way to enable **bootupd** is by providing a machine config.

- Provide a machine config file with the enabled **systemd** unit, as shown in the following example:

Example output

```
variant: rhcos
version: 1.1.0
systemd:
  units:
    - name: custom-bootupd-auto.service
      enabled: true
      contents: |
        [Unit]
        Description=Bootupd automatic update

        [Service]
        ExecStart=/usr/bin/bootupctl update
        RemainAfterExit=yes

        [Install]
        WantedBy=multi-user.target
```

21.5.17. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.

IMPORTANT

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.11. Download and install the new version of **oc**.

Installing the OpenShift CLI on Linux

You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the architecture in the **Product Variant** drop-down menu.
3. Select the appropriate version in the **Version** drop-down menu.
4. Click **Download Now** next to the **OpenShift v4.11 Linux Client** entry and save the file.
5. Unpack the archive:

```
$ tar xvf <file>
```

6. Place the **oc** binary in a directory that is on your **PATH**.
   To check your **PATH**, execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.
   To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
C:\> oc <command>
```

Installing the OpenShift CLI on macOS

You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 macOS Client** entry and save the file.

NOTE

For macOS arm64, choose the **OpenShift v4.11 macOS arm64 Client** entry.

4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your PATH.
   To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

21.5.18. Waiting for the bootstrap process to complete

The OpenShift Container Platform bootstrap process begins after the cluster nodes first boot into the persistent RHCOS environment that has been installed to disk. The configuration information provided through the Ignition config files is used to initialize the bootstrap process and install OpenShift Container Platform on the machines. You must wait for the bootstrap process to complete.

Prerequisites

- You have created the Ignition config files for your cluster.
- You have configured suitable network, DNS and load balancing infrastructure.
- You have obtained the installation program and generated the Ignition config files for your cluster.
- You installed RHCOS on your cluster machines and provided the Ignition config files that the OpenShift Container Platform installation program generated.
- Your machines have direct internet access or have an HTTP or HTTPS proxy available.

Procedure

1. Monitor the bootstrap process:

```
$ ./openshift-install --dir <installation_directory> wait-for bootstrap-complete \ 1
    --log-level=info 2
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

Example output

```
INFO Waiting up to 30m0s for the Kubernetes API at https://api.test.example.com:6443...
INFO API v1.24.0 up
INFO Waiting up to 30m0s for bootstrapping to complete...
INFO It is now safe to remove the bootstrap resources
```

The command succeeds when the Kubernetes API server signals that it has been bootstrapped on the control plane machines.

2. After the bootstrap process is complete, remove the bootstrap machine from the load balancer.

IMPORTANT

You must remove the bootstrap machine from the load balancer at this point. You can also remove or reformat the bootstrap machine itself.

21.5.19. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

Example output

```
system:admin
```

21.5.20. Approving the certificate signing requests for your machines

When you add machines to a cluster, two pending certificate signing requests (CSRs) are generated for each machine that you added. You must confirm that these CSRs are approved or, if necessary, approve them yourself. The client requests must be approved first, followed by the server requests.

Prerequisites

- You added machines to your cluster.

Procedure

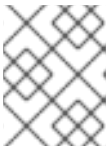
1. Confirm that the cluster recognizes the machines:

```
$ oc get nodes
```

Example output

```
NAME      STATUS    ROLES   AGE  VERSION
master-0  Ready     master  63m  v1.24.0
master-1  Ready     master  63m  v1.24.0
master-2  Ready     master  64m  v1.24.0
```

The output lists all of the machines that you created.



NOTE

The preceding output might not include the compute nodes, also known as worker nodes, until some CSRs are approved.

2. Review the pending CSRs and ensure that you see the client requests with the **Pending** or **Approved** status for each machine that you added to the cluster:

```
$ oc get csr
```

Example output

```
NAME        AGE     REQUESTOR                                                   CONDITION
csr-8b2br   15m     system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper   Pending
csr-8vnps   15m     system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper   Pending
...
```

In this example, two machines are joining the cluster. You might see more approved CSRs in the list.

3. If the CSRs were not approved, after all of the pending CSRs for the machines you added are in **Pending** status, approve the CSRs for your cluster machines:

NOTE

Because the CSRs rotate automatically, approve your CSRs within an hour of adding the machines to the cluster. If you do not approve them within an hour, the certificates will rotate, and more than two certificates will be present for each node. You must approve all of these certificates. After the client CSR is approved, the Kubelet creates a secondary CSR for the serving certificate, which requires manual approval. Then, subsequent serving certificate renewal requests are automatically approved by the **machine-approver** if the Kubelet requests a new certificate with identical parameters.

NOTE

For clusters running on platforms that are not machine API enabled, such as bare metal and other user-provisioned infrastructure, you must implement a method of automatically approving the kubelet serving certificate requests (CSRs). If a request is not approved, then the **oc exec**, **oc rsh**, and **oc logs** commands cannot succeed, because a serving certificate is required when the API server connects to the kubelet. Any operation that contacts the Kubelet endpoint requires this certificate approval to be in place. The method must watch for new CSRs, confirm that the CSR was submitted by the **node-bootstrapper** service account in the **system:node** or **system:admin** groups, and confirm the identity of the node.

- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

1 **<csr_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{{"\n"}}
{{end}}{{end}}' | xargs --no-run-if-empty oc adm certificate approve
```

NOTE

Some Operators might not become available until some CSRs are approved.

4. Now that your client requests are approved, you must review the server requests for each machine that you added to the cluster:

```
$ oc get csr
```

Example output

```
NAME        AGE     REQUESTOR                                                   CONDITION
csr-bfd72   5m26s   system:node:ip-10-0-50-126.us-east-2.compute.internal
Pending
csr-c57lv   5m26s   system:node:ip-10-0-95-157.us-east-2.compute.internal
Pending
...
```

5. If the remaining CSRs are not approved, and are in the **Pending** status, approve the CSRs for your cluster machines:

   - To approve them individually, run the following command for each valid CSR:

     ```
     $ oc adm certificate approve <csr_name> 1
     ```

     1 **<csr_name>** is the name of a CSR from the list of current CSRs.

   - To approve all pending CSRs, run the following command:

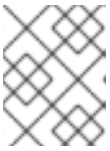
     ```
     $ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{{"\n"}}
     {{end}}{{end}}' | xargs oc adm certificate approve
     ```

6. After all client and server CSRs have been approved, the machines have the **Ready** status. Verify this by running the following command:

   ```
   $ oc get nodes
   ```

   Example output

   ```
   NAME      STATUS    ROLES   AGE  VERSION
   master-0  Ready     master  73m  v1.24.0
   master-1  Ready     master  73m  v1.24.0
   master-2  Ready     master  74m  v1.24.0
   worker-0  Ready     worker  11m  v1.24.0
   worker-1  Ready     worker  11m  v1.24.0
   ```

   NOTE

   It can take a few minutes after approval of the server CSRs for the machines to transition to the **Ready** status.

Additional information

- For more information on CSRs, see Certificate Signing Requests.

21.5.21. Initial Operator configuration

After the control plane initializes, you must immediately configure some Operators so that they all become available.

Prerequisites

- Your control plane has initialized.

Procedure

1. Watch the cluster components come online:

   ```
   $ watch -n5 oc get clusteroperators
   ```

Example output

```
NAME                                       VERSION   AVAILABLE   PROGRESSING   DEGRADED
SINCE
authentication                             4.11.0    True        False         False      19m
baremetal                                  4.11.0    True        False         False      37m
cloud-credential                           4.11.0    True        False         False      40m
cluster-autoscaler                         4.11.0    True        False         False      37m
config-operator                            4.11.0    True        False         False      38m
console                                    4.11.0    True        False         False      26m
csi-snapshot-controller                    4.11.0    True        False         False      37m
dns                                        4.11.0    True        False         False      37m
etcd                                       4.11.0    True        False         False      36m
image-registry                             4.11.0    True        False         False      31m
ingress                                    4.11.0    True        False         False      30m
insights                                   4.11.0    True        False         False      31m
kube-apiserver                             4.11.0    True        False         False      26m
kube-controller-manager                    4.11.0    True        False         False      36m
kube-scheduler                             4.11.0    True        False         False      36m
kube-storage-version-migrator              4.11.0    True        False         False      37m
machine-api                                4.11.0    True        False         False      29m
machine-approver                           4.11.0    True        False         False      37m
machine-config                             4.11.0    True        False         False      36m
marketplace                                4.11.0    True        False         False      37m
monitoring                                 4.11.0    True        False         False      29m
network                                    4.11.0    True        False         False      38m
node-tuning                                4.11.0    True        False         False      37m
openshift-apiserver                        4.11.0    True        False         False      32m
openshift-controller-manager               4.11.0    True        False         False      30m
openshift-samples                          4.11.0    True        False         False      32m
operator-lifecycle-manager                 4.11.0    True        False         False      37m
operator-lifecycle-manager-catalog         4.11.0    True        False         False      37m
operator-lifecycle-manager-packageserver   4.11.0    True        False         False      32m
service-ca                                 4.11.0    True        False         False      38m
storage                                    4.11.0    True        False         False      37m
```

2. Configure the Operators that are not available.

21.5.21.1. Image registry removed during installation

On platforms that do not provide shareable object storage, the OpenShift Image Registry Operator bootstraps itself as **Removed**. This allows **openshift-installer** to complete installations on these platform types.

After installation, you must edit the Image Registry Operator configuration to switch the **managementState** from **Removed** to **Managed**.

21.5.21.2. Image registry storage configuration

The Image Registry Operator is not initially available for platforms that do not provide default storage. After installation, you must configure your registry to use storage so that the Registry Operator is made available.

Instructions are shown for configuring a persistent volume, which is required for production clusters. Where applicable, instructions are shown for configuring an empty directory as the storage location, which is available for only non-production clusters.

Additional instructions are provided for allowing the image registry to use block storage types by using the **Recreate** rollout strategy during upgrades.

21.5.21.2.1. Configuring registry storage for VMware vSphere

As a cluster administrator, following installation you must configure your registry to use storage.

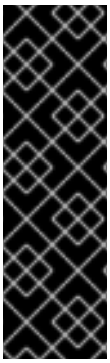
Prerequisites

- Cluster administrator permissions.
- A cluster on VMware vSphere.
- Persistent storage provisioned for your cluster, such as Red Hat OpenShift Data Foundation.

IMPORTANT

OpenShift Container Platform supports **ReadWriteOnce** access for image registry storage when you have only one replica. **ReadWriteOnce** access also requires that the registry uses the **Recreate** rollout strategy. To deploy an image registry that supports high availability with two or more replicas, **ReadWriteMany** access is required.

- Must have "100Gi" capacity.



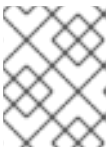
IMPORTANT

Testing shows issues with using the NFS server on RHEL as storage backend for core services. This includes the OpenShift Container Registry and Quay, Prometheus for monitoring storage, and Elasticsearch for logging storage. Therefore, using RHEL NFS to back PVs used by core services is not recommended.

Other NFS implementations on the marketplace might not have these issues. Contact the individual NFS implementation vendor for more information on any testing that was possibly completed against these OpenShift Container Platform core components.

Procedure

1. To configure your registry to use storage, change the **spec.storage.pvc** in the **configs.imageregistry/cluster** resource.



NOTE

When you use shared storage, review your security settings to prevent outside access.

2. Verify that you do not have a registry pod:

```
$ oc get pod -n openshift-image-registry -l docker-registry=default
```

Example output

```
No resourses found in openshift-image-registry namespace
```

NOTE

If you do have a registry pod in your output, you do not need to continue with this procedure.

3. Check the registry configuration:

```
$ oc edit configs.imageregistry.operator.openshift.io
```

Example output

```
storage:
  pvc:
    claim: 1
```

1 Leave the **claim** field blank to allow the automatic creation of an **image-registry-storage** persistent volume claim (PVC). The PVC is generated based on the default storage class. However, be aware that the default storage class might provide ReadWriteOnce (RWO) volumes, such as a RADOS Block Device (RBD), which can cause issues when you replicate to more than one replica.

4. Check the **clusteroperator** status:

```
$ oc get clusteroperator image-registry
```

Example output

```
NAME             VERSION                             AVAILABLE   PROGRESSING   DEGRADED
SINCE   MESSAGE
image-registry   4.7                                 True        False         False      6h50m
```

21.5.21.2.2. Configuring storage for the image registry in non-production clusters

You must configure storage for the Image Registry Operator. For non-production clusters, you can set the image registry to an empty directory. If you do so, all images are lost if you restart the registry.

Procedure

- To set the image registry storage to an empty directory:

```
$ oc patch configs.imageregistry.operator.openshift.io cluster --type merge --patch '{"spec":
{"storage":{"emptyDir":{}}}}'
```

WARNING

Configure this option for only non-production clusters.

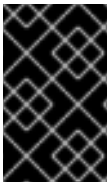
If you run this command before the Image Registry Operator initializes its components, the **oc patch** command fails with the following error:

```
Error from server (NotFound): configs.imageregistry.operator.openshift.io "cluster" not found
```

Wait a few minutes and run the command again.

21.5.21.2.3. Configuring block registry storage for VMware vSphere

To allow the image registry to use block storage types such as vSphere Virtual Machine Disk (VMDK) during upgrades as a cluster administrator, you can use the **Recreate** rollout strategy.



IMPORTANT

Block storage volumes are supported but not recommended for use with image registry on production clusters. An installation where the registry is configured on block storage is not highly available because the registry cannot have more than one replica.

Procedure

1. Enter the following command to set the image registry storage as a block storage type, patch the registry so that it uses the **Recreate** rollout strategy, and runs with only **1** replica:

```
$ oc patch config.imageregistry.operator.openshift.io/cluster --type=merge -p '{"spec":
{"rolloutStrategy":"Recreate","replicas":1}}'
```

2. Provision the PV for the block storage device, and create a PVC for that volume. The requested block volume uses the ReadWriteOnce (RWO) access mode.

   a. Create a **pvc.yaml** file with the following contents to define a VMware vSphere **PersistentVolumeClaim** object:

```
kind: PersistentVolumeClaim
apiVersion: v1
metadata:
  name: image-registry-storage 1
  namespace: openshift-image-registry 2
spec:
  accessModes:
  - ReadWriteOnce 3
  resources:
    requests:
      storage: 100Gi 4
```

1 A unique name that represents the **PersistentVolumeClaim** object.

2. The namespace for the **PersistentVolumeClaim** object, which is **openshift-image-registry**.
3. The access mode of the persistent volume claim. With **ReadWriteOnce**, the volume can be mounted with read and write permissions by a single node.
4. The size of the persistent volume claim.

b. Enter the following command to create the **PersistentVolumeClaim** object from the file:

```
$ oc create -f pvc.yaml -n openshift-image-registry
```

3. Enter the following command to edit the registry configuration so that it references the correct PVC:

```
$ oc edit config.imageregistry.operator.openshift.io -o yaml
```

Example output

```
storage:
  pvc:
    claim: 1
```

1. By creating a custom PVC, you can leave the **claim** field blank for the default automatic creation of an **image-registry-storage** PVC.

For instructions about configuring registry storage so that it references the correct PVC, see Configuring the registry for vSphere.

21.5.22. Completing installation on user-provisioned infrastructure

After you complete the Operator configuration, you can finish installing the cluster on infrastructure that you provide.

Prerequisites

- Your control plane has initialized.
- You have completed the initial Operator configuration.

Procedure

1. Confirm that all the cluster components are online with the following command:

```
$ watch -n5 oc get clusteroperators
```

Example output

```
NAME                                       VERSION   AVAILABLE   PROGRESSING   DEGRADED
SINCE
authentication                             4.11.0    True        False         False     19m
```

```
baremetal                                  4.11.0    True        False        False      37m
cloud-credential                           4.11.0    True        False        False      40m
cluster-autoscaler                         4.11.0    True        False        False      37m
config-operator                            4.11.0    True        False        False      38m
console                                    4.11.0    True        False        False      26m
csi-snapshot-controller                    4.11.0    True        False        False      37m
dns                                        4.11.0    True        False        False      37m
etcd                                       4.11.0    True        False        False      36m
image-registry                             4.11.0    True        False        False      31m
ingress                                    4.11.0    True        False        False      30m
insights                                   4.11.0    True        False        False      31m
kube-apiserver                             4.11.0    True        False        False      26m
kube-controller-manager                    4.11.0    True        False        False      36m
kube-scheduler                             4.11.0    True        False        False      36m
kube-storage-version-migrator              4.11.0    True        False        False      37m
machine-api                                4.11.0    True        False        False      29m
machine-approver                           4.11.0    True        False        False      37m
machine-config                             4.11.0    True        False        False      36m
marketplace                                4.11.0    True        False        False      37m
monitoring                                 4.11.0    True        False        False      29m
network                                    4.11.0    True        False        False      38m
node-tuning                                4.11.0    True        False        False      37m
openshift-apiserver                        4.11.0    True        False        False      32m
openshift-controller-manager               4.11.0    True        False        False      30m
openshift-samples                          4.11.0    True        False        False      32m
operator-lifecycle-manager                 4.11.0    True        False        False      37m
operator-lifecycle-manager-catalog         4.11.0    True        False        False      37m
operator-lifecycle-manager-packageserver   4.11.0    True        False        False      32m
service-ca                                 4.11.0    True        False        False      38m
storage                                    4.11.0    True        False        False      37m
```

Alternatively, the following command notifies you when all of the clusters are available. It also retrieves and displays credentials:

```
$ ./openshift-install --dir <installation_directory> wait-for install-complete 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

Example output

```
INFO Waiting up to 30m0s for the cluster to initialize...
```

The command succeeds when the Cluster Version Operator finishes deploying the OpenShift Container Platform cluster from Kubernetes API server.

IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

2. Confirm that the Kubernetes API server is communicating with the pods.

   a. To view a list of all pods, use the following command:

   ```
   $ oc get pods --all-namespaces
   ```

   Example output

   ```
   NAMESPACE                       NAME                                        READY   STATUS
   RESTARTS   AGE
   openshift-apiserver-operator    openshift-apiserver-operator-85cb746d55-zqhs8   1/1
   Running    1          9m
   openshift-apiserver             apiserver-67b9g                               1/1     Running     0
   3m
   openshift-apiserver             apiserver-ljcmx                               1/1     Running     0
   1m
   openshift-apiserver             apiserver-z25h4                               1/1     Running     0
   2m
   openshift-authentication-operator authentication-operator-69d5d8bf84-vh2n8        1/1
   Running    0          5m
   ...
   ```

   b. View the logs for a pod that is listed in the output of the previous command by using the following command:

   ```
   $ oc logs <pod_name> -n <namespace> 1
   ```

   1 Specify the pod name and namespace, as shown in the output of the previous command.

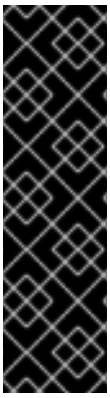
   If the pod logs display, the Kubernetes API server can communicate with the cluster machines.

3. For an installation with Fibre Channel Protocol (FCP), additional steps are required to enable multipathing. Do not enable multipathing during installation.
   See "Enabling multipathing with kernel arguments on RHCOS" in the *Post-installation machine configuration tasks* documentation for more information.

You can add extra compute machines after the cluster installation is completed by following Adding compute machines to vSphere.

21.5.23. Configuring vSphere DRS anti-affinity rules for control plane nodes

vSphere Distributed Resource Scheduler (DRS) anti-affinity rules can be configured to support higher availability of OpenShift Container Platform control plane nodes. Anti-affinity rules ensure that the vSphere Virtual Machines for the OpenShift Container Platform control plane nodes are not scheduled to the same vSphere Host.



IMPORTANT

- The following information applies to compute DRS only and does not apply to storage DRS.
- The **govc`** command is an open-source command available from VMware; it is not available from Red Hat. The **govc** command is not supported by the Red Hat support.
- Instructions for downloading and installing **govc** are found on the VMware documentation website.

Create an anti-affinity rule by running the following command:

Example command

```
$ govc cluster.rule.create \
  -name openshift4-control-plane-group \
  -dc MyDatacenter -cluster MyCluster \
  -enable \
  -anti-affinity master-0 master-1 master-2
```

After creating the rule, your control plane nodes are automatically migrated by vSphere so they are not running on the same hosts. This might take some time while vSphere reconciles the new rule. Successful command completion is shown in the following procedure.

NOTE

The migration occurs automatically and might cause brief OpenShift API outage or latency until the migration finishes.

The vSphere DRS anti-affinity rules need to be updated manually in the event of a control plane VM name change or migration to a new vSphere Cluster.

Procedure

1. Remove any existing DRS anti-affinity rule by running the following command:

```
$ govc cluster.rule.remove \
  -name openshift4-control-plane-group \
  -dc MyDatacenter -cluster MyCluster
```

Example Output

```
[13-10-22 09:33:24] Reconfigure /MyDatacenter/host/MyCluster...OK
```

2. Create the rule again with updated names by running the following command:

```
$ govc cluster.rule.create \
  -name openshift4-control-plane-group \
  -dc MyDatacenter -cluster MyOtherCluster \
  -enable \
  -anti-affinity master-0 master-1 master-2
```

21.5.24. Backing up VMware vSphere volumes

OpenShift Container Platform provisions new volumes as independent persistent disks to freely attach and detach the volume on any node in the cluster. As a consequence, it is not possible to back up volumes that use snapshots, or to restore volumes from snapshots. See Snapshot Limitations for more information.

Procedure

To create a backup of persistent volumes:

1. Stop the application that is using the persistent volume.
2. Clone the persistent volume.
3. Restart the application.
4. Create a backup of the cloned volume.
5. Delete the cloned volume.

21.5.25. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.11, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to OpenShift Cluster Manager Hybrid Cloud Console.

After you confirm that your OpenShift Cluster Manager Hybrid Cloud Console inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, use subscription watch to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

Additional resources

- See About remote health monitoring for more information about the Telemetry service

21.5.26. Next steps

- Customize your cluster.
- If necessary, you can opt out of remote health reporting .
- Set up your registry and configure registry storage .

- Optional: View the events from the vSphere Problem Detector Operator to determine if the cluster has permission or storage configuration issues.

21.6. INSTALLING A CLUSTER ON VSPHERE WITH NETWORK CUSTOMIZATIONS

In OpenShift Container Platform version 4.11, you can install a cluster on VMware vSphere infrastructure that you provision with customized network configuration options. By customizing your network configuration, your cluster can coexist with existing IP address allocations in your environment and integrate with existing MTU and VXLAN configurations.

NOTE

OpenShift Container Platform supports deploying a cluster to a single VMware vCenter only. Deploying a cluster with machines/machine sets on multiple vCenters is not supported.

You must set most of the network configuration parameters during installation, and you can modify only **kubeProxy** configuration parameters in a running cluster.

IMPORTANT

The steps for performing a user-provisioned infrastructure installation are provided as an example only. Installing a cluster with infrastructure you provide requires knowledge of the vSphere platform and the installation process of OpenShift Container Platform. Use the user-provisioned infrastructure installation instructions as a guide; you are free to create the required resources through other methods.

21.6.1. Prerequisites

- You reviewed details about the OpenShift Container Platform installation and update processes.
- You read the documentation on selecting a cluster installation method and preparing it for users.
- Completing the installation requires that you upload the Red Hat Enterprise Linux CoreOS (RHCOS) OVA on vSphere hosts. The machine from which you complete this process requires access to port 443 on the vCenter and ESXi hosts. Verify that port 443 is accessible.
- If you use a firewall, you confirmed with the administrator that port 443 is accessible. Control plane nodes must be able to reach vCenter and ESXi hosts on port 443 for the installation to succeed.
- If you use a firewall, you configured it to allow the sites that your cluster requires access to.

21.6.2. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.11, you require access to the internet to install your cluster.

You must have internet access to:

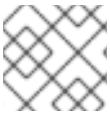
- Access OpenShift Cluster Manager Hybrid Cloud Console to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access Quay.io to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.

IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

21.6.3. VMware vSphere infrastructure requirements

You must install the OpenShift Container Platform cluster on a VMware vSphere version 7 instance that meets the requirements for the components that you use.



NOTE

OpenShift Container Platform version 4.11 does not support VMware vSphere version 8.0.

You can host the VMware vSphere infrastructure on-premise or on a VMware Cloud Verified provider that meets the requirements outlined in the following table:

Table 21.48. Version requirements for vSphere virtual environments

Virtual environment product	Required version
VM hardware version	15 or later
vSphere ESXi hosts	7
vCenter host	7

IMPORTANT

Installing a cluster on VMware vSphere version 7.0 Update 1 or earlier is now deprecated. These versions are still fully supported, but version 4.11 of OpenShift Container Platform requires vSphere virtual hardware version 15 or later. Hardware version 15 is now the default for vSphere virtual machines in OpenShift Container Platform. To update the hardware version for your vSphere nodes, see the "Updating hardware on nodes running in vSphere" article.

If your vSphere nodes are below hardware version 15 or your VMware vSphere version is earlier than 6.7.3, upgrading from OpenShift Container Platform 4.10 to OpenShift Container Platform 4.11 is not available.

Table 21.49. Minimum supported vSphere version for VMware components

Component	Minimum supported versions	Description
Hypervisor	vSphere 7 with HW version 15	This version is the minimum version that Red Hat Enterprise Linux CoreOS (RHCOS) supports. For more information about supported hardware on the latest version of Red Hat Enterprise Linux (RHEL) that is compatible with RHCOS, see Hardware on the Red Hat Customer Portal.
Storage with in-tree drivers	vSphere 7	This plugin creates vSphere storage by using the in-tree storage drivers for vSphere included in OpenShift Container Platform.
Optional: Networking (NSX-T)	vSphere 7	vSphere 7 is required for OpenShift Container Platform. For more information about the compatibility of NSX and OpenShift Container Platform, see the Release Notes section of VMware's NSX container plugin documentation.

IMPORTANT

You must ensure that the time on your ESXi hosts is synchronized before you install OpenShift Container Platform. See Edit Time Configuration for a Host in the VMware documentation.

21.6.4. VMware vSphere CSI Driver Operator requirements

To install the vSphere CSI Driver Operator, the following requirements must be met:

- VMware vSphere version 7.0 Update 1 or later
- Virtual machines of hardware version 15 or later
- No third-party vSphere CSI driver already installed in the cluster

IMPORTANT

If a third-party vSphere CSI driver is present in the cluster, OpenShift Container Platform does not overwrite it. If you continue with the third-party vSphere CSI driver when upgrading to the next major version of OpenShift Container Platform, the **oc** CLI prompts you with the following message:

```
VSphereCSIDriverOperatorCRUpgradeable: VMwareVSphereControllerUpgradeable:
found existing unsupported csi.vsphere.vmware.com driver
```

The previous message informs you that Red Hat does not support the third-party vSphere CSI driver during an OpenShift Container Platform upgrade operation. You can choose to ignore this message and continue with the upgrade operation.

Additional resources

- To remove a third-party vSphere CSI driver, see Removing a third-party vSphere CSI Driver .
- To update the hardware version for your vSphere nodes, see Updating hardware on nodes running in vSphere.

21.6.5. Requirements for a cluster with user-provisioned infrastructure

For a cluster that contains user-provisioned infrastructure, you must deploy all of the required machines.

This section describes the requirements for deploying OpenShift Container Platform on user-provisioned infrastructure.

21.6.5.1. Required machines for cluster installation

The smallest OpenShift Container Platform clusters require the following hosts:

Table 21.50. Minimum required hosts

Hosts	Description
One temporary bootstrap machine	The cluster requires the bootstrap machine to deploy the OpenShift Container Platform cluster on the three control plane machines. You can remove the bootstrap machine after you install the cluster.
Three control plane machines	The control plane machines run the Kubernetes and OpenShift Container Platform services that form the control plane.
At least two compute machines, which are also known as worker machines.	The workloads requested by OpenShift Container Platform users run on the compute machines.

IMPORTANT

To maintain high availability of your cluster, use separate physical hosts for these cluster machines.

The bootstrap and control plane machines must use Red Hat Enterprise Linux CoreOS (RHCOS) as the operating system. However, the compute machines can choose between Red Hat Enterprise Linux CoreOS (RHCOS), Red Hat Enterprise Linux (RHEL) 8.6 and later.

Note that RHCOS is based on Red Hat Enterprise Linux (RHEL) 8 and inherits all of its hardware certifications and requirements. See Red Hat Enterprise Linux technology capabilities and limits .

21.6.5.2. Minimum resource requirements for cluster installation

Each cluster machine must meet the following minimum requirements:

Table 21.51. Minimum resource requirements

Machine	Operating System	vCPU	Virtual RAM	Storage	Input/Output Per Second (IOPS)[1]
Bootstrap	RHCOS	4	16 GB	100 GB	300
Control plane	RHCOS	4	16 GB	100 GB	300
Compute	RHCOS, RHEL 8.6 and later [2]	2	8 GB	100 GB	300

1. OpenShift Container Platform and Kubernetes are sensitive to disk performance, and faster storage is recommended, particularly for etcd on the control plane nodes which require a 10 ms p99 fsync duration. Note that on many cloud platforms, storage size and IOPS scale together, so you might need to over-allocate storage volume to obtain sufficient performance.

2. As with all user-provisioned installations, if you choose to use RHEL compute machines in your cluster, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks. Use of RHEL 7 compute machines is deprecated and has been removed in OpenShift Container Platform 4.10 and later.

If an instance type for your platform meets the minimum requirements for cluster machines, it is supported to use in OpenShift Container Platform.

Additional resources

- Optimizing storage

21.6.5.3. Certificate signing requests management

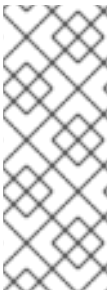
Because your cluster has limited access to automatic machine management when you use infrastructure that you provision, you must provide a mechanism for approving cluster certificate signing requests (CSRs) after installation. The **kube-controller-manager** only approves the kubelet client CSRs. The **machine-approver** cannot guarantee the validity of a serving certificate that is requested by using kubelet credentials because it cannot confirm that the correct machine issued the request. You must determine and implement a method of verifying the validity of the kubelet serving certificate requests and approving them.

21.6.5.4. Networking requirements for user-provisioned infrastructure

All the Red Hat Enterprise Linux CoreOS (RHCOS) machines require networking to be configured in **initramfs** during boot to fetch their Ignition config files.

During the initial boot, the machines require an IP address configuration that is set either through a DHCP server or statically by providing the required boot options. After a network connection is established, the machines download their Ignition config files from an HTTP or HTTPS server. The Ignition config files are then used to set the exact state of each machine. The Machine Config Operator completes more changes to the machines, such as the application of new certificates or keys, after installation.

It is recommended to use a DHCP server for long-term management of the cluster machines. Ensure that the DHCP server is configured to provide persistent IP addresses, DNS server information, and hostnames to the cluster machines.



NOTE

If a DHCP service is not available for your user-provisioned infrastructure, you can instead provide the IP networking configuration and the address of the DNS server to the nodes at RHCOS install time. These can be passed as boot arguments if you are installing from an ISO image. See the *Installing RHCOS and starting the OpenShift Container Platform bootstrap process* section for more information about static IP provisioning and advanced networking options.

The Kubernetes API server must be able to resolve the node names of the cluster machines. If the API servers and worker nodes are in different zones, you can configure a default DNS search zone to allow the API server to resolve the node names. Another supported approach is to always refer to hosts by their fully-qualified domain names in both the node objects and all DNS requests.

21.6.5.4.1. Setting the cluster node hostnames through DHCP

On Red Hat Enterprise Linux CoreOS (RHCOS) machines, the hostname is set through NetworkManager. By default, the machines obtain their hostname through DHCP. If the hostname is not provided by DHCP, set statically through kernel arguments, or another method, it is obtained through a reverse DNS lookup. Reverse DNS lookup occurs after the network has been initialized on a node and can take time to resolve. Other system services can start prior to this and detect the hostname as **localhost** or similar. You can avoid this by using DHCP to provide the hostname for each cluster node.

Additionally, setting the hostnames through DHCP can bypass any manual DNS record name configuration errors in environments that have a DNS split-horizon implementation.

21.6.5.4.2. Network connectivity requirements

You must configure the network connectivity between machines to allow OpenShift Container Platform cluster components to communicate. Each machine must be able to resolve the hostnames of all other machines in the cluster.

This section provides details about the ports that are required.

IMPORTANT

In connected OpenShift Container Platform environments, all nodes are required to have internet access to pull images for platform containers and provide telemetry data to Red Hat.

Table 21.52. Ports used for all-machine to all-machine communications

Protocol	Port	Description
ICMP	N/A	Network reachability tests
TCP	**1936**	Metrics
	9000-**9999**	Host level services, including the node exporter on ports **9100**-**9101** and the Cluster Version Operator on port**9099**.
	10250-**10259**	The default ports that Kubernetes reserves
	10256	openshift-sdn
UDP	**4789**	VXLAN
	6081	Geneve
	9000-**9999**	Host level services, including the node exporter on ports **9100**-**9101**.
	500	IPsec IKE packets
	4500	IPsec NAT-T packets
TCP/UDP	**30000**-**32767**	Kubernetes node port
ESP	N/A	IPsec Encapsulating Security Payload (ESP)

Table 21.53. Ports used for all-machine to control plane communications

Protocol	Port	Description
TCP	**6443**	Kubernetes API

Table 21.54. Ports used for control plane machine to control plane machine communications

Protocol	Port	Description
TCP	**2379**-**2380**	etcd server and peer ports

Ethernet adaptor hardware address requirements

When provisioning VMs for the cluster, the ethernet interfaces configured for each VM must use a MAC address from the VMware Organizationally Unique Identifier (OUI) allocation ranges:

- **00:05:69:00:00:00** to **00:05:69:FF:FF:FF**

- **00:0c:29:00:00:00** to **00:0c:29:FF:FF:FF**
- **00:1c:14:00:00:00** to **00:1c:14:FF:FF:FF**
- **00:50:56:00:00:00** to **00:50:56:3F:FF:FF**

If a MAC address outside the VMware OUI is used, the cluster installation will not succeed.

NTP configuration for user-provisioned infrastructure
OpenShift Container Platform clusters are configured to use a public Network Time Protocol (NTP) server by default. If you want to use a local enterprise NTP server, or if your cluster is being deployed in a disconnected network, you can configure the cluster to use a specific time server. For more information, see the documentation for *Configuring chrony time service* .

If a DHCP server provides NTP server information, the chrony time service on the Red Hat Enterprise Linux CoreOS (RHCOS) machines read the information and can sync the clock with the NTP servers.

Additional resources

- Configuring chrony time service

21.6.5.5. User-provisioned DNS requirements

In OpenShift Container Platform deployments, DNS name resolution is required for the following components:

- The Kubernetes API
- The OpenShift Container Platform application wildcard
- The bootstrap, control plane, and compute machines

Reverse DNS resolution is also required for the Kubernetes API, the bootstrap machine, the control plane machines, and the compute machines.

DNS A/AAAA or CNAME records are used for name resolution and PTR records are used for reverse name resolution. The reverse records are important because Red Hat Enterprise Linux CoreOS (RHCOS) uses the reverse records to set the hostnames for all the nodes, unless the hostnames are provided by DHCP. Additionally, the reverse records are used to generate the certificate signing requests (CSR) that OpenShift Container Platform needs to operate.

NOTE

It is recommended to use a DHCP server to provide the hostnames to each cluster node. See the *DHCP recommendations for user-provisioned infrastructure* section for more information.

The following DNS records are required for a user-provisioned OpenShift Container Platform cluster and they must be in place before installation. In each record, **<cluster_name>** is the cluster name and **<base_domain>** is the base domain that you specify in the **install-config.yaml** file. A complete DNS record takes the form: **<component>.<cluster_name>.<base_domain>.**.

Table 21.55. Required DNS records

Component	Record	Description
Kubernetes API	**api.<cluster_name>.<base_domain>.**	A DNS A/AAAA or CNAME record, and a DNS PTR record, to identify the API load balancer. These records must be resolvable by both clients external to the cluster and from all the nodes within the cluster.
	api-int.<cluster_name>.<base_domain>.	A DNS A/AAAA or CNAME record, and a DNS PTR record, to internally identify the API load balancer. These records must be resolvable from all the nodes within the cluster.  **IMPORTANT** The API server must be able to resolve the worker nodes by the hostnames that are recorded in Kubernetes. If the API server cannot resolve the node names, then proxied API calls can fail, and you cannot retrieve logs from pods.
Routes	***.apps.<cluster_name>.<base_domain>.**	A wildcard DNS A/AAAA or CNAME record that refers to the application ingress load balancer. The application ingress load balancer targets the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default. These records must be resolvable by both clients external to the cluster and from all the nodes within the cluster. For example, **console-openshift-console.apps.<cluster_name>.<base_domain>** is used as a wildcard route to the OpenShift Container Platform console.
Bootstrap machine	**bootstrap.<cluster_name>.<base_domain>.**	A DNS A/AAAA or CNAME record, and a DNS PTR record, to identify the bootstrap machine. These records must be resolvable by the nodes within the cluster.
Control plane machines	**<master><n>.<cluster_name>.<base_domain>.**	DNS A/AAAA or CNAME records and DNS PTR records to identify each machine for the control plane nodes. These records must be resolvable by the nodes within the cluster.
Compute machines	**<worker><n>.<cluster_name>.<base_domain>.**	DNS A/AAAA or CNAME records and DNS PTR records to identify each machine for the worker nodes. These records must be resolvable by the nodes within the cluster.

NOTE

In OpenShift Container Platform 4.4 and later, you do not need to specify etcd host and SRV records in your DNS configuration.

TIP

You can use the **dig** command to verify name and reverse name resolution. See the section on *Validating DNS resolution for user-provisioned infrastructure* for detailed validation steps.

21.6.5.5.1. Example DNS configuration for user-provisioned clusters

This section provides A and PTR record configuration samples that meet the DNS requirements for deploying OpenShift Container Platform on user-provisioned infrastructure. The samples are not meant to provide advice for choosing one DNS solution over another.

In the examples, the cluster name is **ocp4** and the base domain is **example.com**.

Example DNS A record configuration for a user-provisioned cluster

The following example is a BIND zone file that shows sample A records for name resolution in a user-provisioned cluster.

Example 21.13. Sample DNS zone database

```
$TTL 1W
@ IN SOA ns1.example.com. root (
  2019070700 ; serial
  3H  ; refresh (3 hours)
  30M  ; retry (30 minutes)
  2W  ; expiry (2 weeks)
  1W )  ; minimum (1 week)
 IN NS ns1.example.com.
 IN MX 10 smtp.example.com.
;
;
ns1.example.com.  IN A 192.168.1.5
smtp.example.com.  IN A 192.168.1.5
;
helper.example.com.  IN A 192.168.1.5
helper.ocp4.example.com. IN A 192.168.1.5
;
api.ocp4.example.com.  IN A 192.168.1.5 1
api-int.ocp4.example.com. IN A 192.168.1.5 2
;
*.apps.ocp4.example.com. IN A 192.168.1.5 3
;
bootstrap.ocp4.example.com. IN A 192.168.1.96 4
;
master0.ocp4.example.com. IN A 192.168.1.97 5
master1.ocp4.example.com. IN A 192.168.1.98 6
master2.ocp4.example.com. IN A 192.168.1.99 7
;
worker0.ocp4.example.com. IN A 192.168.1.11 8
worker1.ocp4.example.com. IN A 192.168.1.7 9
;
;EOF
```

1 Provides name resolution for the Kubernetes API. The record refers to the IP address of the API load balancer.

2 Provides name resolution for the Kubernetes API. The record refers to the IP address of the API load balancer and is used for internal cluster communications.

3 Provides name resolution for the wildcard routes. The record refers to the IP address of the application ingress load balancer. The application ingress load balancer targets the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.

NOTE

In the example, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

4 Provides name resolution for the bootstrap machine.

5 6 7 Provides name resolution for the control plane machines.

8 9 Provides name resolution for the compute machines.

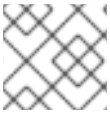
Example DNS PTR record configuration for a user-provisioned cluster

The following example BIND zone file shows sample PTR records for reverse name resolution in a user-provisioned cluster.

Example 21.14. Sample DNS zone database for reverse records

```
$TTL 1W
@ IN SOA ns1.example.com. root (
  2019070700 ; serial
  3H  ; refresh (3 hours)
  30M  ; retry (30 minutes)
  2W  ; expiry (2 weeks)
  1W )  ; minimum (1 week)
 IN NS ns1.example.com.
;
5.1.168.192.in-addr.arpa. IN PTR api.ocp4.example.com. 1
5.1.168.192.in-addr.arpa. IN PTR api-int.ocp4.example.com. 2
;
96.1.168.192.in-addr.arpa. IN PTR bootstrap.ocp4.example.com. 3
;
97.1.168.192.in-addr.arpa. IN PTR master0.ocp4.example.com. 4
98.1.168.192.in-addr.arpa. IN PTR master1.ocp4.example.com. 5
99.1.168.192.in-addr.arpa. IN PTR master2.ocp4.example.com. 6
;
11.1.168.192.in-addr.arpa. IN PTR worker0.ocp4.example.com. 7
7.1.168.192.in-addr.arpa. IN PTR worker1.ocp4.example.com. 8
;
;EOF
```

1. Provides reverse DNS resolution for the Kubernetes API. The PTR record refers to the record name of the API load balancer.
2. Provides reverse DNS resolution for the Kubernetes API. The PTR record refers to the record name of the API load balancer and is used for internal cluster communications.
3. Provides reverse DNS resolution for the bootstrap machine.
4 5 6. Provides reverse DNS resolution for the control plane machines.
7 8. Provides reverse DNS resolution for the compute machines.

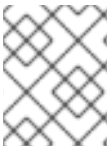


NOTE

A PTR record is not required for the OpenShift Container Platform application wildcard.

21.6.5.6. Load balancing requirements for user-provisioned infrastructure

Before you install OpenShift Container Platform, you must provision the API and application ingress load balancing infrastructure. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

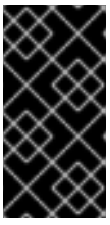


NOTE

If you want to deploy the API and application Ingress load balancers with a Red Hat Enterprise Linux (RHEL) instance, you must purchase the RHEL subscription separately.

The load balancing infrastructure must meet the following requirements:

1. **API load balancer**: Provides a common endpoint for users, both human and machine, to interact with and configure the platform. Configure the following conditions:
   - Layer 4 load balancing only. This can be referred to as Raw TCP, SSL Passthrough, or SSL Bridge mode. If you use SSL Bridge mode, you must enable Server Name Indication (SNI) for the API routes.
   - A stateless load balancing algorithm. The options vary based on the load balancer implementation.



IMPORTANT

Do not configure session persistence for an API load balancer. Configuring session persistence for a Kubernetes API server might cause performance issues from excess application traffic for your OpenShift Container Platform cluster and the Kubernetes API that runs inside the cluster.

Configure the following ports on both the front and back of the load balancers:

Table 21.56. API load balancer

Port	Back-end machines (pool members)	Internal	External	Description
6443	Bootstrap and control plane. You remove the bootstrap machine from the load balancer after the bootstrap machine initializes the cluster control plane. You must configure the **/readyz** endpoint for the API server health check probe.	X	X	Kubernetes API server
22623	Bootstrap and control plane. You remove the bootstrap machine from the load balancer after the bootstrap machine initializes the cluster control plane.	X		Machine config server

NOTE

The load balancer must be configured to take a maximum of 30 seconds from the time the API server turns off the **/readyz** endpoint to the removal of the API server instance from the pool. Within the time frame after **/readyz** returns an error or becomes healthy, the endpoint must have been removed or added. Probing every 5 or 10 seconds, with two successful requests to become healthy and three to become unhealthy, are well-tested values.

2. **Application Ingress load balancer**: Provides an ingress point for application traffic flowing in from outside the cluster. A working configuration for the Ingress router is required for an OpenShift Container Platform cluster.
Configure the following conditions:

   - Layer 4 load balancing only. This can be referred to as Raw TCP, SSL Passthrough, or SSL Bridge mode. If you use SSL Bridge mode, you must enable Server Name Indication (SNI) for the ingress routes.
   - A connection-based or session-based persistence is recommended, based on the options available and types of applications that will be hosted on the platform.

TIP

If the true IP address of the client can be seen by the application Ingress load balancer, enabling source IP-based session persistence can improve performance for applications that use end-to-end TLS encryption.

Configure the following ports on both the front and back of the load balancers:

Table 21.57. Application Ingress load balancer

Port	Back-end machines (pool members)	Internal	External	Description

Port	Back-end machines (pool members)	Internal	External	Description
443	The machines that run the Ingress Controller pods, compute, or worker, by default.	X	X	HTTPS traffic
80	The machines that run the Ingress Controller pods, compute, or worker, by default.	X	X	HTTP traffic

NOTE

If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application Ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes.

21.6.5.6.1. Example load balancer configuration for user-provisioned clusters

This section provides an example API and application ingress load balancer configuration that meets the load balancing requirements for user-provisioned clusters. The sample is an **/etc/haproxy/haproxy.cfg** configuration for an HAProxy load balancer. The example is not meant to provide advice for choosing one load balancing solution over another.

In the example, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

NOTE

If you are using HAProxy as a load balancer and SELinux is set to **enforcing**, you must ensure that the HAProxy service can bind to the configured TCP port by running **setsebool -P haproxy_connect_any=1**.

Example 21.15. Sample API and application Ingress load balancer configuration

```
global
  log         127.0.0.1 local2
  pidfile     /var/run/haproxy.pid
  maxconn     4000
  daemon
defaults
  mode                    http
  log                     global
  option                  dontlognull
  option http-server-close
  option                  redispatch
  retries                 3
  timeout http-request    10s
  timeout queue           1m
  timeout connect         10s
  timeout client          1m
```

```
  timeout server          1m
  timeout http-keep-alive 10s
  timeout check           10s
  maxconn                 3000
listen api-server-6443 1
  bind *:6443
  mode tcp
  server bootstrap bootstrap.ocp4.example.com:6443 check inter 1s backup 2
  server master0 master0.ocp4.example.com:6443 check inter 1s
  server master1 master1.ocp4.example.com:6443 check inter 1s
  server master2 master2.ocp4.example.com:6443 check inter 1s
listen machine-config-server-22623 3
  bind *:22623
  mode tcp
  option  httpchk GET /readyz HTTP/1.0
  option  log-health-checks
  balance roundrobin
  server bootstrap bootstrap.ocp4.example.com:6443 verify none check check-ssl inter 10s fall 2
rise 3 backup 4
  server master0 master0.ocp4.example.com:6443 weight 1 verify none check check-ssl inter 10s
fall 2 rise 3
  server master1 master1.ocp4.example.com:6443 weight 1 verify none check check-ssl inter 10s
fall 2 rise 3
  server master2 master2.ocp4.example.com:6443 weight 1 verify none check check-ssl inter 10s
fall 2 rise 3
listen ingress-router-443 5
  bind *:443
  mode tcp
  balance source
  server worker0 worker0.ocp4.example.com:443 check inter 1s
  server worker1 worker1.ocp4.example.com:443 check inter 1s
listen ingress-router-80 6
  bind *:80
  mode tcp
  balance source
  server worker0 worker0.ocp4.example.com:80 check inter 1s
  server worker1 worker1.ocp4.example.com:80 check inter 1s
```

1 Port **6443** handles the Kubernetes API traffic and points to the control plane machines.

2 4 The bootstrap entries must be in place before the OpenShift Container Platform cluster installation and they must be removed after the bootstrap process is complete.

3 Port **22623** handles the machine config server traffic and points to the control plane machines.

5 Port **443** handles the HTTPS traffic and points to the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.

6 Port **80** handles the HTTP traffic and points to the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.

NOTE

If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application Ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes.

TIP

If you are using HAProxy as a load balancer, you can check that the **haproxy** process is listening on ports **6443**, **22623**, **443**, and **80** by running **netstat -nltupe** on the HAProxy node.

21.6.6. Preparing the user-provisioned infrastructure

Before you install OpenShift Container Platform on user-provisioned infrastructure, you must prepare the underlying infrastructure.

This section provides details about the high-level steps required to set up your cluster infrastructure in preparation for an OpenShift Container Platform installation. This includes configuring IP networking and network connectivity for your cluster nodes, enabling the required ports through your firewall, and setting up the required DNS and load balancing infrastructure.

After preparation, your cluster infrastructure must meet the requirements outlined in the *Requirements for a cluster with user-provisioned infrastructure* section.

Prerequisites

- You have reviewed the OpenShift Container Platform 4.x Tested Integrations page.
- You have reviewed the infrastructure requirements detailed in the *Requirements for a cluster with user-provisioned infrastructure* section.

Procedure

1. If you are using DHCP to provide the IP networking configuration to your cluster nodes, configure your DHCP service.
   a. Add persistent IP addresses for the nodes to your DHCP server configuration. In your configuration, match the MAC address of the relevant network interface to the intended IP address for each node.
   b. When you use DHCP to configure IP addressing for the cluster machines, the machines also obtain the DNS server information through DHCP. Define the persistent DNS server address that is used by the cluster nodes through your DHCP server configuration.

NOTE

If you are not using a DHCP service, you must provide the IP networking configuration and the address of the DNS server to the nodes at RHCOS install time. These can be passed as boot arguments if you are installing from an ISO image. See the *Installing RHCOS and starting the OpenShift Container Platform bootstrap process* section for more information about static IP provisioning and advanced networking options.

c. Define the hostnames of your cluster nodes in your DHCP server configuration. See the *Setting the cluster node hostnames through DHCP* section for details about hostname considerations.

NOTE

If you are not using a DHCP service, the cluster nodes obtain their hostname through a reverse DNS lookup.

2. Ensure that your network infrastructure provides the required network connectivity between the cluster components. See the *Networking requirements for user-provisioned infrastructure* section for details about the requirements.

3. Configure your firewall to enable the ports required for the OpenShift Container Platform cluster components to communicate. See *Networking requirements for user-provisioned infrastructure* section for details about the ports that are required.

IMPORTANT

By default, port **1936** is accessible for an OpenShift Container Platform cluster, because each control plane node needs access to this port.

Avoid using the Ingress load balancer to expose this port, because doing so might result in the exposure of sensitive information, such as statistics and metrics, related to Ingress Controllers.

4. Setup the required DNS infrastructure for your cluster.

   a. Configure DNS name resolution for the Kubernetes API, the application wildcard, the bootstrap machine, the control plane machines, and the compute machines.

   b. Configure reverse DNS resolution for the Kubernetes API, the bootstrap machine, the control plane machines, and the compute machines.
   See the *User-provisioned DNS requirements* section for more information about the OpenShift Container Platform DNS requirements.

5. Validate your DNS configuration.

   a. From your installation node, run DNS lookups against the record names of the Kubernetes API, the wildcard routes, and the cluster nodes. Validate that the IP addresses in the responses correspond to the correct components.

   b. From your installation node, run reverse DNS lookups against the IP addresses of the load balancer and the cluster nodes. Validate that the record names in the responses correspond to the correct components.
   See the *Validating DNS resolution for user-provisioned infrastructure* section for detailed DNS validation steps.

6. Provision the required API and application ingress load balancing infrastructure. See the *Load balancing requirements for user-provisioned infrastructure* section for more information about the requirements.

NOTE

Some load balancing solutions require the DNS name resolution for the cluster nodes to be in place before the load balancing is initialized.

21.6.7. Validating DNS resolution for user-provisioned infrastructure

You can validate your DNS configuration before installing OpenShift Container Platform on user-provisioned infrastructure.

IMPORTANT

The validation steps detailed in this section must succeed before you install your cluster.

Prerequisites

- You have configured the required DNS records for your user-provisioned infrastructure.

Procedure

1. From your installation node, run DNS lookups against the record names of the Kubernetes API, the wildcard routes, and the cluster nodes. Validate that the IP addresses contained in the responses correspond to the correct components.

   a. Perform a lookup against the Kubernetes API record name. Check that the result points to the IP address of the API load balancer:

   ```
   $ dig +noall +answer @<nameserver_ip> api.<cluster_name>.<base_domain> 1
   ```

   1 Replace **<nameserver_ip>** with the IP address of the nameserver, **<cluster_name>** with your cluster name, and **<base_domain>** with your base domain name.

   Example output

   ```
   api.ocp4.example.com.  604800 IN A 192.168.1.5
   ```

   b. Perform a lookup against the Kubernetes internal API record name. Check that the result points to the IP address of the API load balancer:

   ```
   $ dig +noall +answer @<nameserver_ip> api-int.<cluster_name>.<base_domain>
   ```

   Example output

   ```
   api-int.ocp4.example.com.  604800 IN A 192.168.1.5
   ```

   c. Test an example ***.apps.<cluster_name>.<base_domain>** DNS wildcard lookup. All of the application wildcard lookups must resolve to the IP address of the application ingress load balancer:

   ```
   $ dig +noall +answer @<nameserver_ip> random.apps.<cluster_name>.<base_domain>
   ```

   Example output

```
random.apps.ocp4.example.com.  604800 IN A 192.168.1.5
```

NOTE

In the example outputs, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

You can replace **random** with another wildcard value. For example, you can query the route to the OpenShift Container Platform console:

```
$ dig +noall +answer @<nameserver_ip> console-openshift-console.apps.
<cluster_name>.<base_domain>
```

Example output

```
console-openshift-console.apps.ocp4.example.com. 604800 IN A 192.168.1.5
```

d. Run a lookup against the bootstrap DNS record name. Check that the result points to the IP address of the bootstrap node:

```
$ dig +noall +answer @<nameserver_ip> bootstrap.<cluster_name>.<base_domain>
```

Example output

```
bootstrap.ocp4.example.com.  604800 IN A 192.168.1.96
```

e. Use this method to perform lookups against the DNS record names for the control plane and compute nodes. Check that the results correspond to the IP addresses of each node.

2. From your installation node, run reverse DNS lookups against the IP addresses of the load balancer and the cluster nodes. Validate that the record names contained in the responses correspond to the correct components.

a. Perform a reverse lookup against the IP address of the API load balancer. Check that the response includes the record names for the Kubernetes API and the Kubernetes internal API:

```
$ dig +noall +answer @<nameserver_ip> -x 192.168.1.5
```

Example output

```
5.1.168.192.in-addr.arpa. 604800 IN PTR api-int.ocp4.example.com. 1
5.1.168.192.in-addr.arpa. 604800 IN PTR api.ocp4.example.com. 2
```

1 Provides the record name for the Kubernetes internal API.

2 Provides the record name for the Kubernetes API.

NOTE

A PTR record is not required for the OpenShift Container Platform application wildcard. No validation step is needed for reverse DNS resolution against the IP address of the application ingress load balancer.

b. Perform a reverse lookup against the IP address of the bootstrap node. Check that the result points to the DNS record name of the bootstrap node:

```
$ dig +noall +answer @<nameserver_ip> -x 192.168.1.96
```

Example output

```
96.1.168.192.in-addr.arpa. 604800 IN PTR bootstrap.ocp4.example.com.
```

c. Use this method to perform reverse lookups against the IP addresses for the control plane and compute nodes. Check that the results correspond to the DNS record names of each node.

21.6.8. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the **~/.ssh/authorized_keys** list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The **./openshift-install gather** command also requires the SSH public key to be in place on the cluster nodes.

IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.

NOTE

You must use a local key, not one that you configured with platform-specific approaches such as AWS key pairs.

Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N '' -f <path>/<file_name> 1
```

1 Specify the path and file name, such as ~/**.ssh/id_ed25519**, of the new SSH key. If you have an existing key pair, ensure your public key is in the your ~/**.ssh** directory.

NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS validated or Modules In Process cryptographic libraries on the **x86_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

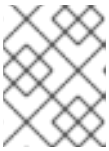
2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the ~/**.ssh/id_ed25519.pub** public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the **./openshift-install gather** command.



NOTE

On some distributions, default SSH private key identities such as ~/**.ssh/id_rsa** and ~/**.ssh/id_dsa** are managed automatically.

a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

Example output

```
Agent pid 31874
```

NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

1 Specify the path and file name for your SSH private key, such as ~/**.ssh/id_ed25519**

Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

21.6.9. Obtaining the installation program

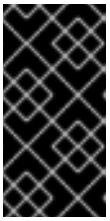
Before you install OpenShift Container Platform, download the installation file on a local computer.

Prerequisites

- You have a computer that runs Linux or macOS, with 500 MB of local disk space.

Procedure

1. Access the Infrastructure Provider page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program that corresponds with your host operating system and architecture, and place the file in the directory where you will store the installation configuration files.



IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.

IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation pull secret from the Red Hat OpenShift Cluster Manager . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

21.6.10. Manually creating the installation configuration file

For user-provisioned installations of OpenShift Container Platform, you manually generate your installation configuration file.

IMPORTANT

The Cluster Cloud Controller Manager Operator performs a connectivity check on a provided hostname or IP address. Ensure that you specify a hostname or an IP address to a reachable vCenter server. If you provide metadata to a non-existent vCenter server, installation of the cluster fails at the bootstrap stage.

Prerequisites

- You have an SSH public key on your local machine to provide to the installation program. The key will be used for SSH authentication onto your cluster nodes for debugging and disaster recovery.
- You have obtained the OpenShift Container Platform installation program and the pull secret for your cluster.

Procedure

1. Create an installation directory to store your required installation assets in:

```
$ mkdir <installation_directory>
```

IMPORTANT

You must create a directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

2. Customize the sample **install-config.yaml** file template that is provided and save it in the **<installation_directory>**.

NOTE

You must name this configuration file **install-config.yaml**.

NOTE

For some platform types, you can alternatively run **./openshift-install create install-config --dir <installation_directory>** to generate an **install-config.yaml** file. You can provide details about your cluster configuration at the prompts.

3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.

IMPORTANT

The **install-config.yaml** file is consumed during the next step of the installation process. You must back it up now.

21.6.10.1. Sample install-config.yaml file for VMware vSphere

You can customize the **install-config.yaml** file to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.

```
apiVersion: v1
baseDomain: example.com (1)
compute: (2)
  name: worker
  replicas: 0 (3)
controlPlane: (4)
  name: master
  replicas: 3 (5)
metadata:
  name: test (6)
platform:
  vsphere:
    vcenter: your.vcenter.server (7)
    username: username (8)
    password: password (9)
    datacenter: datacenter (10)
    defaultDatastore: datastore (11)
    folder: "/<datacenter_name>/vm/<folder_name>/<subfolder_name>" (12)
    resourcePool: "/<datacenter_name>/host/<cluster_name>/Resources/<resource_pool_name>" (13)
    diskType: thin (14)
fips: false (15)
pullSecret: '{"auths": ...}' (16)
sshKey: 'ssh-ed25519 AAAA...' (17)
```

(1) The base domain of the cluster. All DNS records must be sub-domains of this base and include the cluster name.

(2) (4) The **controlPlane** section is a single mapping, but the compute section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, (**-**), and the first line of the **controlPlane** section must not. Although both sections currently define a single machine pool, it is possible that future versions of OpenShift Container Platform will support defining multiple compute pools during installation. Only one control plane pool is used.

(3) You must set the value of the **replicas** parameter to **0**. This parameter controls the number of workers that the cluster creates and manages for you, which are functions that the cluster does not perform when you use user-provisioned infrastructure. You must manually deploy worker machines for the cluster to use before you finish installing OpenShift Container Platform.

(5) The number of control plane machines that you add to the cluster. Because the cluster uses this values as the number of etcd endpoints in the cluster, the value must match the number of control plane machines that you deploy.

(6) The cluster name that you specified in your DNS records.

(7) The fully-qualified hostname or IP address of the vCenter server.

IMPORTANT

The Cluster Cloud Controller Manager Operator performs a connectivity check on a provided hostname or IP address. Ensure that you specify a hostname or an IP address to a reachable vCenter server. If you provide metadata to a non-existent vCenter server, installation of the cluster fails at the bootstrap stage.

8. The name of the user for accessing the server.
9. The password associated with the vSphere user.
10. The vSphere datacenter.
11. The default vSphere datastore to use.
12. Optional parameter: For installer-provisioned infrastructure, the absolute path of an existing folder where the installation program creates the virtual machines, for example, **/<datacenter_name>/vm/<folder_name>/<subfolder_name>**. If you do not provide this value, the installation program creates a top-level folder in the datacenter virtual machine folder that is named with the infrastructure ID. If you are providing the infrastructure for the cluster and you do not want to use the default **StorageClass** object, named **thin**, you can omit the **folder** parameter from the **install-config.yaml** file.
13. Optional parameter: For installer-provisioned infrastructure, the absolute path of an existing folder where the installation program creates the virtual machines, for example, **/<datacenter_name>/vm/<folder_name>/<subfolder_name>**. If you do not provide this value, the installation program creates a top-level folder in the datacenter virtual machine folder that is named with the infrastructure ID. If you are providing the infrastructure for the cluster, omit this parameter.
14. The vSphere disk provisioning method.
15. Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.

IMPORTANT

To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.

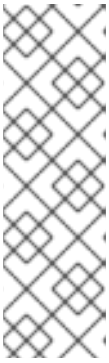
16. The pull secret that you obtained from OpenShift Cluster Manager Hybrid Cloud Console . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.
17. The public portion of the default SSH key for the **core** user in Red Hat Enterprise Linux CoreOS (RHCOS).

21.6.10.2. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.



NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
```

1. A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
2. A proxy URL to use for creating HTTPS connections outside the cluster.
3. A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use ***** to bypass the proxy for all destinations. You must include vCenter's IP address and the IP range that you use for its machines.
4. If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace that contains one or more additional CA certificates that are required for proxying HTTPS connections. The Cluster Network Operator then

creates a **trusted-ca-bundle** config map that merges these contents with the Red Hat Enterprise Linux CoreOS (RHCOS) trust bundle, and this config map is referenced in the **trustedCA** field of the **Proxy** object. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.

NOTE

The installation program does not support the proxy **readinessEndpoints** field.

NOTE

If the installer times out, restart and then complete the deployment by using the **wait-for** command of the installer. For example:

```
$ ./openshift-install wait-for install-complete --log-level debug
```

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.

NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

21.6.11. Network configuration phases

There are two phases prior to OpenShift Container Platform installation where you can customize the network configuration.

Phase 1

You can customize the following network-related fields in the **install-config.yaml** file before you create the manifest files:

- **networking.networkType**
- **networking.clusterNetwork**
- **networking.serviceNetwork**
- **networking.machineNetwork**
  For more information on these fields, refer to *Installation configuration parameters*.

NOTE

Set the **networking.machineNetwork** to match the CIDR that the preferred NIC resides in.

IMPORTANT

The CIDR range **172.17.0.0/16** is reserved by libVirt. You cannot use this range or any range that overlaps with this range for any networks in your cluster.

Phase 2

After creating the manifest files by running **openshift-install create manifests**, you can define a customized Cluster Network Operator manifest with only the fields you want to modify. You can use the manifest to specify advanced network configuration.

You cannot override the values specified in phase 1 in the **install-config.yaml** file during phase 2. However, you can further customize the cluster network provider during phase 2.

21.6.12. Specifying advanced network configuration

You can use advanced network configuration for your cluster network provider to integrate your cluster into your existing network environment. You can specify advanced network configuration only before you install the cluster.

IMPORTANT

Customizing your network configuration by modifying the OpenShift Container Platform manifest files created by the installation program is not supported. Applying a manifest file that you create, as in the following procedure, is supported.

Prerequisites

- You have created the **install-config.yaml** file and completed any modifications to it.

Procedure

1. Change to the directory that contains the installation program and create the manifests:

```
$ ./openshift-install create manifests --dir <installation_directory> 1
```

1 **<installation_directory>** specifies the name of the directory that contains the **install-config.yaml** file for your cluster.

2. Create a stub manifest file for the advanced network configuration that is named **cluster-network-03-config.yml** in the **<installation_directory>/manifests/** directory:

```
apiVersion: operator.openshift.io/v1
kind: Network
metadata:
  name: cluster
spec:
```

3. Specify the advanced network configuration for your cluster in the **cluster-network-03-config.yml** file, such as in the following examples:

Specify a different VXLAN port for the OpenShift SDN network provider

```
apiVersion: operator.openshift.io/v1
kind: Network
metadata:
  name: cluster
spec:
  defaultNetwork:
    openshiftSDNConfig:
      vxlanPort: 4800
```

Enable IPsec for the OVN-Kubernetes network provider

```
apiVersion: operator.openshift.io/v1
kind: Network
metadata:
  name: cluster
spec:
  defaultNetwork:
    ovnKubernetesConfig:
      ipsecConfig: {}
```

4. Optional: Back up the **manifests/cluster-network-03-config.yml** file. The installation program consumes the **manifests/** directory when you create the Ignition config files.

5. Remove the Kubernetes manifest files that define the control plane machines and compute machineSets:

```
$ rm -f openshift/99_openshift-cluster-api_master-machines-*.yaml openshift/99_openshift-cluster-api_worker-machineset-*.yaml
```

Because you create and manage these resources yourself, you do not have to initialize them.

- You can preserve the MachineSet files to create compute machines by using the machine API, but you must update references to them to match your environment.

21.6.13. Cluster Network Operator configuration

The configuration for the cluster network is specified as part of the Cluster Network Operator (CNO) configuration and stored in a custom resource (CR) object that is named **cluster**. The CR specifies the fields for the **Network** API in the **operator.openshift.io** API group.

The CNO configuration inherits the following fields during cluster installation from the **Network** API in the **Network.config.openshift.io** API group and these fields cannot be changed:

clusterNetwork

IP address pools from which pod IP addresses are allocated.

serviceNetwork

IP address pool for services.

defaultNetwork.type

Cluster network provider, such as OpenShift SDN or OVN-Kubernetes.

You can specify the cluster network provider configuration for your cluster by setting the fields for the **defaultNetwork** object in the CNO object named **cluster**.

21.6.13.1. Cluster Network Operator configuration object

The fields for the Cluster Network Operator (CNO) are described in the following table:

Table 21.58. Cluster Network Operator configuration object

Field	Type	Description
metadata.name	**string**	The name of the CNO object. This name is always **cluster**.
spec.clusterNetwork	**array**	A list specifying the blocks of IP addresses from which pod IP addresses are allocated and the subnet prefix length assigned to each individual node in the cluster. For example: `spec:` `  clusterNetwork:` `  - cidr: 10.128.0.0/19` `  hostPrefix: 23` `  - cidr: 10.128.32.0/19` `  hostPrefix: 23` You can customize this field only in the **install-config.yaml** file before you create the manifests. The value is read-only in the manifest file.
spec.serviceNetwork	**array**	A block of IP addresses for services. The OpenShift SDN and OVN-Kubernetes Container Network Interface (CNI) network providers support only a single IP address block for the service network. For example: `spec:` `  serviceNetwork:` `  - 172.30.0.0/14` You can customize this field only in the **install-config.yaml** file before you create the manifests. The value is read-only in the manifest file.
spec.defaultNetwork	**object**	Configures the Container Network Interface (CNI) cluster network provider for the cluster network.
spec.kubeProxyConfig	**object**	The fields for this object specify the kube-proxy configuration. If you are using the OVN-Kubernetes cluster network provider, the kube-proxy configuration has no effect.

defaultNetwork object configuration

The values for the **defaultNetwork** object are defined in the following table:

Table 21.59. defaultNetwork object

Field	Type	Description
type	**string**	Either **OpenShiftSDN** or **OVNKubernetes**. The cluster network provider is selected during installation. This value cannot be changed after cluster installation.  **NOTE** OpenShift Container Platform uses the OpenShift SDN Container Network Interface (CNI) cluster network provider by default.
openshiftSDNConfig	**object**	This object is only valid for the OpenShift SDN cluster network provider.
ovnKubernetesConfig	**object**	This object is only valid for the OVN-Kubernetes cluster network provider.

Configuration for the OpenShift SDN CNI cluster network provider
The following table describes the configuration fields for the OpenShift SDN Container Network Interface (CNI) cluster network provider.

Table 21.60. **openshiftSDNConfig** object

Field	Type	Description
mode	**string**	Configures the network isolation mode for OpenShift SDN. The default value is **NetworkPolicy**. The values **Multitenant** and **Subnet** are available for backwards compatibility with OpenShift Container Platform 3.x but are not recommended. This value cannot be changed after cluster installation.

Field	Type	Description
mtu	**integer**	The maximum transmission unit (MTU) for the VXLAN overlay network. This is detected automatically based on the MTU of the primary network interface. You do not normally need to override the detected MTU. If the auto-detected value is not what you expect it to be, confirm that the MTU on the primary network interface on your nodes is correct. You cannot use this option to change the MTU value of the primary network interface on the nodes. If your cluster requires different MTU values for different nodes, you must set this value to **50** less than the lowest MTU value in your cluster. For example, if some nodes in your cluster have an MTU of **9001**, and some have an MTU of**1500**, you must set this value to **1450**. This value cannot be changed after cluster installation.
vxlanPort	**integer**	The port to use for all VXLAN packets. The default value is **4789**. This value cannot be changed after cluster installation. If you are running in a virtualized environment with existing nodes that are part of another VXLAN network, then you might be required to change this. For example, when running an OpenShift SDN overlay on top of VMware NSX-T, you must select an alternate port for the VXLAN, because both SDNs use the same default VXLAN port number. On Amazon Web Services (AWS), you can select an alternate port for the VXLAN between port **9000** and port **9999**.

Example OpenShift SDN configuration

```
defaultNetwork:
  type: OpenShiftSDN
  openshiftSDNConfig:
    mode: NetworkPolicy
    mtu: 1450
    vxlanPort: 4789
```

Configuration for the OVN-Kubernetes CNI cluster network provider

The following table describes the configuration fields for the OVN-Kubernetes CNI cluster network provider.

Table 21.61. **ovnKubernetesConfig** object

Field	Type	Description

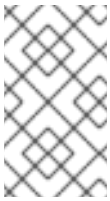
Field	Type	Description
mtu	**integer**	The maximum transmission unit (MTU) for the Geneve (Generic Network Virtualization Encapsulation) overlay network. This is detected automatically based on the MTU of the primary network interface. You do not normally need to override the detected MTU. If the auto-detected value is not what you expect it to be, confirm that the MTU on the primary network interface on your nodes is correct. You cannot use this option to change the MTU value of the primary network interface on the nodes. If your cluster requires different MTU values for different nodes, you must set this value to **100** less than the lowest MTU value in your cluster. For example, if some nodes in your cluster have an MTU of **9001**, and some have an MTU of**1500**, you must set this value to **1400**.
genevePort	**integer**	The port to use for all Geneve packets. The default value is **6081**. This value cannot be changed after cluster installation.
ipsecConfig	**object**	Specify an empty object to enable IPsec encryption.
policyAuditConfig	**object**	Specify a configuration object for customizing network policy audit logging. If unset, the defaults audit log settings are used.
gatewayConfig	**object**	Optional: Specify a configuration object for customizing how egress traffic is sent to the node gateway.  **NOTE** While migrating egress traffic, you can expect some disruption to workloads and service traffic until the Cluster Network Operator (CNO) successfully rolls out the changes.

Table 21.62. **policyAuditConfig** object

Field	Type	Description
rateLimit	integer	The maximum number of messages to generate every second per node. The default value is **20** messages per second.
maxFileSize	integer	The maximum size for the audit log in bytes. The default value is **50000000** or 50 MB.

Field	Type	Description
destination	string	One of the following additional audit log targets: **libc** The libc **syslog()** function of the journald process on the host. **udp:<host>:<port>** A syslog server. Replace **<host>:<port>** with the host and port of the syslog server. **unix:<file>** A Unix Domain Socket file specified by **<file>**. **null** Do not send the audit logs to any additional target.
syslogFacility	string	The syslog facility, such as **kern**, as defined by RFC5424. The default value is **local0**.

Table 21.63. **gatewayConfig** object

Field	Type	Description
routingViaHost	**boolean**	Set this field to **true** to send egress traffic from pods to the host networking stack. For highly-specialized installations and applications that rely on manually configured routes in the kernel routing table, you might want to route egress traffic to the host networking stack. By default, egress traffic is processed in OVN to exit the cluster and is not affected by specialized routes in the kernel routing table. The default value is **false**. This field has an interaction with the Open vSwitch hardware offloading feature. If you set this field to **true**, you do not receive the performance benefits of the offloading because egress traffic is processed by the host networking stack.

Example OVN-Kubernetes configuration with IPSec enabled

```
defaultNetwork:
  type: OVNKubernetes
  ovnKubernetesConfig:
    mtu: 1400
    genevePort: 6081
    ipsecConfig: {}
```

kubeProxyConfig object configuration

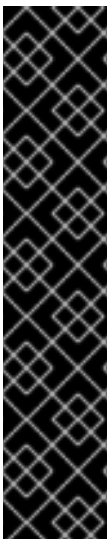
The values for the **kubeProxyConfig** object are defined in the following table:

Table 21.64. **kubeProxyConfig** object

Field	Type	Description
iptablesSyncPeriod	**string**	The refresh period for **iptables** rules. The default value is **30s**. Valid suffixes include **s**, **m**, and **h** and are described in the Go **time** package documentation.  **NOTE** Because of performance improvements introduced in OpenShift Container Platform 4.3 and greater, adjusting the **iptablesSyncPeriod** parameter is no longer necessary.
proxyArguments.iptables-min-sync-period	**array**	The minimum duration before refreshing **iptables** rules. This field ensures that the refresh does not happen too frequently. Valid suffixes include **s**, **m**, and **h** and are described in the Go **time** package. The default value is: `kubeProxyConfig:` `  proxyArguments:` `  iptables-min-sync-period:` `  - 0s`

21.6.14. Creating the Ignition config files

Because you must manually start the cluster machines, you must generate the Ignition config files that the cluster needs to make its machines.



IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

Prerequisites

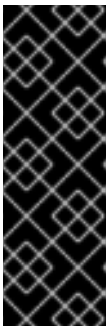
- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.

Procedure

- Obtain the Ignition config files:

```
$ ./openshift-install create ignition-configs --dir <installation_directory> 1
```

1 For **<installation_directory>**, specify the directory name to store the files that the installation program creates.



IMPORTANT

If you created an **install-config.yaml** file, specify the directory that contains it. Otherwise, specify an empty directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

The following files are generated in the directory:

```
.
├── auth
│   ├── kubeadmin-password
│   └── kubeconfig
├── bootstrap.ign
├── master.ign
├── metadata.json
└── worker.ign
```

21.6.15. Extracting the infrastructure name

The Ignition config files contain a unique cluster identifier that you can use to uniquely identify your cluster in VMware vSphere. If you plan to use the cluster identifier as the name of your virtual machine folder, you must extract it.

Prerequisites

- You obtained the OpenShift Container Platform installation program and the pull secret for your cluster.
- You generated the Ignition config files for your cluster.
- You installed the **jq** package.

Procedure

- To extract and view the infrastructure name from the Ignition config file metadata, run the following command:

```
$ jq -r .infraID <installation_directory>/metadata.json 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

Example output

```
openshift-vw9j6 1
```

1 The output of this command is your cluster name and a random string.

21.6.16. Installing RHCOS and starting the OpenShift Container Platform bootstrap process

To install OpenShift Container Platform on user-provisioned infrastructure on VMware vSphere, you must install Red Hat Enterprise Linux CoreOS (RHCOS) on vSphere hosts. When you install RHCOS, you must provide the Ignition config file that was generated by the OpenShift Container Platform installation program for the type of machine you are installing. If you have configured suitable networking, DNS, and load balancing infrastructure, the OpenShift Container Platform bootstrap process begins automatically after the RHCOS machines have rebooted.

Prerequisites

- You have obtained the Ignition config files for your cluster.
- You have access to an HTTP server that you can access from your computer and that the machines that you create can access.
- You have created a vSphere cluster.

Procedure

1. Upload the bootstrap Ignition config file, which is named **<installation_directory>/bootstrap.ign**, that the installation program created to your HTTP server. Note the URL of this file.
2. Save the following secondary Ignition config file for your bootstrap node to your computer as **<installation_directory>/merge-bootstrap.ign**:

```
{
  "ignition": {
    "config": {
      "merge": [
        {
          "source": "<bootstrap_ignition_config_url>", 1
          "verification": {}
        }
      ]
    },
    "timeouts": {},
    "version": "3.2.0"
  },
  "networkd": {},
  "passwd": {},
```

```
  "storage": {},
  "systemd": {}
}
```

1 Specify the URL of the bootstrap Ignition config file that you hosted.

When you create the virtual machine (VM) for the bootstrap machine, you use this Ignition config file.

3. Locate the following Ignition config files that the installation program created:
   - **<installation_directory>/master.ign**
   - **<installation_directory>/worker.ign**
   - **<installation_directory>/merge-bootstrap.ign**
4. Convert the Ignition config files to Base64 encoding. Later in this procedure, you must add these files to the extra configuration parameter **guestinfo.ignition.config.data** in your VM. For example, if you use a Linux operating system, you can use the **base64** command to encode the files.

```
$ base64 -w0 <installation_directory>/master.ign > <installation_directory>/master.64
```

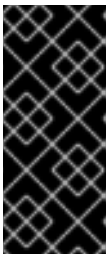
```
$ base64 -w0 <installation_directory>/worker.ign > <installation_directory>/worker.64
```

```
$ base64 -w0 <installation_directory>/merge-bootstrap.ign > <installation_directory>/merge-bootstrap.64
```

IMPORTANT

If you plan to add more compute machines to your cluster after you finish installation, do not delete these files.

5. Obtain the RHCOS OVA image. Images are available from the RHCOS image mirror page.



IMPORTANT

The RHCOS images might not change with every release of OpenShift Container Platform. You must download an image with the highest version that is less than or equal to the OpenShift Container Platform version that you install. Use the image version that matches your OpenShift Container Platform version if it is available.

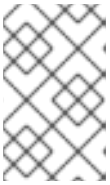
The filename contains the OpenShift Container Platform version number in the format **rhcos-vmware.<architecture>.ova**.

6. In the vSphere Client, create a folder in your datacenter to store your VMs.
   a. Click the **VMs and Templates** view.
   b. Right-click the name of your datacenter.

c. Click **New Folder → New VM and Template Folder**.

d. In the window that is displayed, enter the folder name. If you did not specify an existing folder in the **install-config.yaml** file, then create a folder with the same name as the infrastructure ID. You use this folder name so vCenter dynamically provisions storage in the appropriate location for its Workspace configuration.

7. In the vSphere Client, create a template for the OVA image and then clone the template as needed.



NOTE

In the following steps, you create a template and then clone the template for all of your cluster machines. You then provide the location for the Ignition config file for that cloned machine type when you provision the VMs.

a. From the **Hosts and Clusters** tab, right-click your cluster name and select **Deploy OVF Template**.

b. On the **Select an OVF** tab, specify the name of the RHCOS OVA file that you downloaded.

c. On the **Select a name and folder** tab, set a **Virtual machine name** for your template, such as **Template-RHCOS**. Click the name of your vSphere cluster and select the folder you created in the previous step.

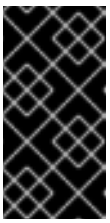
d. On the **Select a compute resource** tab, click the name of your vSphere cluster.

e. On the **Select storage** tab, configure the storage options for your VM.

- Select **Thin Provision** or **Thick Provision**, based on your storage preferences.
- Select the datastore that you specified in your **install-config.yaml** file.

f. On the **Select network** tab, specify the network that you configured for the cluster, if available.

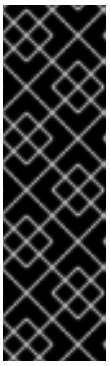
g. When creating the OVF template, do not specify values on the **Customize template** tab or configure the template any further.



IMPORTANT

Do not start the original VM template. The VM template must remain off and must be cloned for new RHCOS machines. Starting the VM template configures the VM template as a VM on the platform, which prevents it from being used as a template that machine sets can apply configurations to.

8. Optional: Update the configured virtual hardware version in the VM template, if necessary. Follow Upgrading a virtual machine to the latest hardware version in the VMware documentation for more information.



IMPORTANT

It is recommended that you update the hardware version of the VM template to version 15 before creating VMs from it, if necessary. Using hardware version 13 for your cluster nodes running on vSphere is now deprecated. If your imported template defaults to hardware version 13, you must ensure that your ESXi host is on 6.7U3 or later before upgrading the VM template to hardware version 15. If your vSphere version is less than 6.7U3, you can skip this upgrade step; however, a future version of OpenShift Container Platform is scheduled to remove support for hardware version 13 and vSphere versions less than 6.7U3.

9. After the template deploys, deploy a VM for a machine in the cluster.

   a. Right-click the template name and click **Clone → Clone to Virtual Machine**

   b. On the **Select a name and folder** tab, specify a name for the VM. You might include the machine type in the name, such as **control-plane-0** or **compute-1**.

NOTE

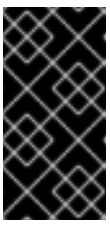
Ensure that all virtual machine names across a vSphere installation are unique.

   c. On the **Select a name and folder** tab, select the name of the folder that you created for the cluster.

   d. On the **Select a compute resource** tab, select the name of a host in your datacenter.

   e. On the **Select clone options**, select **Customize this virtual machine's hardware**.

   f. Optional: On the **Customize hardware** tab, click **VM Options → Advanced**.



IMPORTANT

The following configuration suggestions are for example purposes only. As a cluster administrator, you must configure resources according to the resource demands placed on your cluster. To best manage cluster resources, consider creating a resource pool from the cluster's root resource pool.

- Override default DHCP networking in vSphere. To enable static IP networking:
  - Set your static IP configuration:

```
$ export IPCFG="ip=<ip>::<gateway>:<netmask>:<hostname>:<iface>:none
nameserver=srv1 [nameserver=srv2 [nameserver=srv3 [...]]]"
```

Example command

```
$ export IPCFG="ip=192.168.100.101::192.168.100.254:255.255.255.0:::none
nameserver=8.8.8.8"
```

- Click **Edit Configuration**, and on the **Configuration Parameters** window, search the list of available parameters for steal clock accounting (**stealclock.enable**). Set the parameter to the value of **TRUE**. Enabling steal clock accounting can help with

troubleshooting cluster issues.

- Click **Add Configuration Params**. Define the following parameter names and values:
  - **disk.EnableUUID**: Specify **TRUE**.
  - **stealclock.enable**: If this parameter was not defined, add it and specify **TRUE**.
  - Create a child resource pool from the cluster's root resource pool. Perform resource allocation in this child resource pool.

g. In the **Virtual Hardware** panel of the **Customize hardware** tab, modify the specified values as required. Ensure that the amount of RAM, CPU, and disk storage meets the minimum requirements for the machine type.

h. Complete the configuration and power on the VM.

i. Check the console output to verify that Ignition ran.

Example command

```
Ignition: ran on 2022/03/14 14:48:33 UTC (this boot)
Ignition: user-provided config was applied
```

10. Create the rest of the machines for your cluster by following the preceding steps for each machine.

IMPORTANT

You must create the bootstrap and control plane machines at this time. Because some pods are deployed on compute machines by default, also create at least two compute machines before you install the cluster.

21.6.17. Adding more compute machines to a cluster in vSphere

You can add more compute machines to a user-provisioned OpenShift Container Platform cluster on VMware vSphere.

Prerequisites

- Obtain the base64-encoded Ignition file for your compute machines.
- You have access to the vSphere template that you created for your cluster.

Procedure

1. After the template deploys, deploy a VM for a machine in the cluster.
   a. Right-click the template's name and click **Clone → Clone to Virtual Machine**
   b. On the **Select a name and folder** tab, specify a name for the VM. You might include the machine type in the name, such as **compute-1**.

NOTE

Ensure that all virtual machine names across a vSphere installation are unique.

c. On the **Select a name and folder** tab, select the name of the folder that you created for the cluster.

d. On the **Select a compute resource** tab, select the name of a host in your datacenter.

e. On the **Select clone options**, select **Customize this virtual machine's hardware**.

f. On the **Customize hardware** tab, click **VM Options → Advanced**.

- Click **Edit Configuration**, and on the **Configuration Parameters** window, click **Add Configuration Params**. Define the following parameter names and values:
  - **guestinfo.ignition.config.data**: Paste the contents of the base64-encoded compute Ignition config file for this machine type.
  - **guestinfo.ignition.config.data.encoding**: Specify **base64**.
  - **disk.EnableUUID**: Specify **TRUE**.

g. In the **Virtual Hardware** panel of the **Customize hardware** tab, modify the specified values as required. Ensure that the amount of RAM, CPU, and disk storage meets the minimum requirements for the machine type. Also, make sure to select the correct network under **Add network adapter** if there are multiple networks available.

h. Complete the configuration and power on the VM.

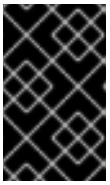
2. Continue to create more compute machines for your cluster.

21.6.18. Disk partitioning

In most cases, data partitions are originally created by installing RHCOS, rather than by installing another operating system. In such cases, the OpenShift Container Platform installer should be allowed to configure your disk partitions.

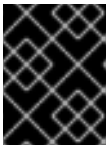
However, there are two cases where you might want to intervene to override the default partitioning when installing an OpenShift Container Platform node:

- Create separate partitions: For greenfield installations on an empty disk, you might want to add separate storage to a partition. This is officially supported for making **/var** or a subdirectory of **/var**, such as **/var/lib/etcd**, a separate partition, but not both.



IMPORTANT

For disk sizes larger than 100GB, and especially disk sizes larger than 1TB, create a separate **/var** partition. See "Creating a separate **/var** partition" and this Red Hat Knowledgebase article for more information.



IMPORTANT

Kubernetes supports only two file system partitions. If you add more than one partition to the original configuration, Kubernetes cannot monitor all of them.

- Retain existing partitions: For a brownfield installation where you are reinstalling OpenShift Container Platform on an existing node and want to retain data partitions installed from your previous operating system, there are both boot arguments and options to **coreos-installer** that allow you to retain existing data partitions.

Creating a separate /var partition

In general, disk partitioning for OpenShift Container Platform should be left to the installer. However, there are cases where you might want to create separate partitions in a part of the filesystem that you expect to grow.

OpenShift Container Platform supports the addition of a single partition to attach storage to either the **/var** partition or a subdirectory of **/var**. For example:

- **/var/lib/containers**: Holds container-related content that can grow as more images and containers are added to a system.
- **/var/lib/etcd**: Holds data that you might want to keep separate for purposes such as performance optimization of etcd storage.
- **/var**: Holds data that you might want to keep separate for purposes such as auditing.

IMPORTANT

For disk sizes larger than 100GB, and especially larger than 1TB, create a separate **/var** partition.

Storing the contents of a **/var** directory separately makes it easier to grow storage for those areas as needed and reinstall OpenShift Container Platform at a later date and keep that data intact. With this method, you will not have to pull all your containers again, nor will you have to copy massive log files when you update systems.

Because **/var** must be in place before a fresh installation of Red Hat Enterprise Linux CoreOS (RHCOS), the following procedure sets up the separate **/var** partition by creating a machine config manifest that is inserted during the **openshift-install** preparation phases of an OpenShift Container Platform installation.

Procedure

1. Create a directory to hold the OpenShift Container Platform installation files:

```
$ mkdir $HOME/clusterconfig
```

2. Run **openshift-install** to create a set of files in the **manifest** and **openshift** subdirectories. Answer the system questions as you are prompted:

```
$ openshift-install create manifests --dir $HOME/clusterconfig
? SSH Public Key ...
$ ls $HOME/clusterconfig/openshift/
99_kubeadmin-password-secret.yaml
99_openshift-cluster-api_master-machines-0.yaml
99_openshift-cluster-api_master-machines-1.yaml
99_openshift-cluster-api_master-machines-2.yaml
...
```

3. Create a Butane config that configures the additional partition. For example, name the file **$HOME/clusterconfig/98-var-partition.bu**, change the disk device name to the name of the storage device on the **worker** systems, and set the storage size as appropriate. This example places the **/var** directory on a separate partition:

```
variant: openshift
version: 4.11.0
metadata:
  labels:
    machineconfiguration.openshift.io/role: worker
  name: 98-var-partition
storage:
  disks:
  - device: /dev/<device_name> 1
    partitions:
    - label: var
      start_mib: <partition_start_offset> 2
      size_mib: <partition_size> 3
  filesystems:
    - device: /dev/disk/by-partlabel/var
      path: /var
      format: xfs
      mount_options: [defaults, prjquota] 4
      with_mount_unit: true
```

1. The storage device name of the disk that you want to partition.
2. When adding a data partition to the boot disk, a minimum value of 25000 mebibytes is recommended. The root file system is automatically resized to fill all available space up to the specified offset. If no value is specified, or if the specified value is smaller than the recommended minimum, the resulting root file system will be too small, and future reinstalls of RHCOS might overwrite the beginning of the data partition.
3. The size of the data partition in mebibytes.
4. The **prjquota** mount option must be enabled for filesystems used for container storage.

NOTE

When creating a separate **/var** partition, you cannot use different instance types for worker nodes, if the different instance types do not have the same device name.

4. Create a manifest from the Butane config and save it to the **clusterconfig/openshift** directory. For example, run the following command:

```
$ butane $HOME/clusterconfig/98-var-partition.bu -o $HOME/clusterconfig/openshift/98-var-partition.yaml
```

5. Run **openshift-install** again to create Ignition configs from a set of files in the **manifest** and **openshift** subdirectories:

```
$ openshift-install create ignition-configs --dir $HOME/clusterconfig
$ ls $HOME/clusterconfig/
auth  bootstrap.ign  master.ign  metadata.json  worker.ign
```

Now you can use the Ignition config files as input to the vSphere installation procedures to install Red Hat Enterprise Linux CoreOS (RHCOS) systems.

21.6.19. Updating the bootloader using bootupd

To update the bootloader by using **bootupd**, you must either install **bootupd** on RHCOS machines manually or provide a machine config with the enabled **systemd** unit. Unlike **grubby** or other bootloader tools, **bootupd** does not manage kernel space configuration such as passing kernel arguments.

After you have installed **bootupd**, you can manage it remotely from the OpenShift Container Platform cluster.

NOTE

It is recommended that you use **bootupd** only on bare metal or virtualized hypervisor installations, such as for protection against the BootHole vulnerability.

Manual install method

You can manually install **bootupd** by using the **bootctl** command-line tool.

1. Inspect the system status:

```
# bootupctl status
```

Example output for x86_64

```
Component EFI
  Installed: grub2-efi-x64-1:2.04-31.fc33.x86_64,shim-x64-15-8.x86_64
  Update: At latest version
```

Example output for aarch64

```
Component EFI
  Installed: grub2-efi-aa64-1:2.02-99.el8_4.1.aarch64,shim-aa64-15.4-2.el8_1.aarch64
  Update: At latest version
```

2. RHCOS images created without **bootupd** installed on them require an explicit adoption phase. If the system status is **Adoptable**, perform the adoption:

```
# bootupctl adopt-and-update
```

Example output

```
Updated: grub2-efi-x64-1:2.04-31.fc33.x86_64,shim-x64-15-8.x86_64
```

3. If an update is available, apply the update so that the changes take effect on the next reboot:

```
# bootupctl update
```

Example output

```
Updated: grub2-efi-x64-1:2.04-31.fc33.x86_64,shim-x64-15-8.x86_64
```

Machine config method

Another way to enable **bootupd** is by providing a machine config.

- Provide a machine config file with the enabled **systemd** unit, as shown in the following example:

Example output

```
variant: rhcos
version: 1.1.0
systemd:
  units:
    - name: custom-bootupd-auto.service
      enabled: true
      contents: |
        [Unit]
        Description=Bootupd automatic update

        [Service]
        ExecStart=/usr/bin/bootupctl update
        RemainAfterExit=yes

        [Install]
        WantedBy=multi-user.target
```

21.6.20. Waiting for the bootstrap process to complete

The OpenShift Container Platform bootstrap process begins after the cluster nodes first boot into the persistent RHCOS environment that has been installed to disk. The configuration information provided through the Ignition config files is used to initialize the bootstrap process and install OpenShift Container Platform on the machines. You must wait for the bootstrap process to complete.

Prerequisites

- You have created the Ignition config files for your cluster.
- You have configured suitable network, DNS and load balancing infrastructure.
- You have obtained the installation program and generated the Ignition config files for your cluster.
- You installed RHCOS on your cluster machines and provided the Ignition config files that the OpenShift Container Platform installation program generated.
- Your machines have direct internet access or have an HTTP or HTTPS proxy available.

Procedure

1. Monitor the bootstrap process:

```
$ ./openshift-install --dir <installation_directory> wait-for bootstrap-complete \ 1
    --log-level=info 2
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

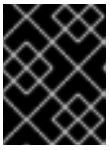
2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

Example output

```
INFO Waiting up to 30m0s for the Kubernetes API at https://api.test.example.com:6443...
INFO API v1.24.0 up
INFO Waiting up to 30m0s for bootstrapping to complete...
INFO It is now safe to remove the bootstrap resources
```

The command succeeds when the Kubernetes API server signals that it has been bootstrapped on the control plane machines.

2. After the bootstrap process is complete, remove the bootstrap machine from the load balancer.



IMPORTANT

You must remove the bootstrap machine from the load balancer at this point. You can also remove or reformat the bootstrap machine itself.

21.6.21. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

-

Example output

```
system:admin
```

21.6.22. Approving the certificate signing requests for your machines

When you add machines to a cluster, two pending certificate signing requests (CSRs) are generated for each machine that you added. You must confirm that these CSRs are approved or, if necessary, approve them yourself. The client requests must be approved first, followed by the server requests.

Prerequisites

- You added machines to your cluster.

Procedure

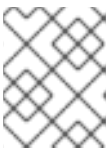
1. Confirm that the cluster recognizes the machines:

```
$ oc get nodes
```

Example output

```
NAME      STATUS    ROLES   AGE  VERSION
master-0  Ready     master  63m  v1.24.0
master-1  Ready     master  63m  v1.24.0
master-2  Ready     master  64m  v1.24.0
```

The output lists all of the machines that you created.



NOTE

The preceding output might not include the compute nodes, also known as worker nodes, until some CSRs are approved.

2. Review the pending CSRs and ensure that you see the client requests with the **Pending** or **Approved** status for each machine that you added to the cluster:

```
$ oc get csr
```

Example output

```
NAME        AGE     REQUESTOR                                                   CONDITION
csr-8b2br   15m     system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper   Pending
csr-8vnps   15m     system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper   Pending
...
```

In this example, two machines are joining the cluster. You might see more approved CSRs in the list.

3. If the CSRs were not approved, after all of the pending CSRs for the machines you added are in **Pending** status, approve the CSRs for your cluster machines:

NOTE

Because the CSRs rotate automatically, approve your CSRs within an hour of adding the machines to the cluster. If you do not approve them within an hour, the certificates will rotate, and more than two certificates will be present for each node. You must approve all of these certificates. After the client CSR is approved, the Kubelet creates a secondary CSR for the serving certificate, which requires manual approval. Then, subsequent serving certificate renewal requests are automatically approved by the **machine-approver** if the Kubelet requests a new certificate with identical parameters.

NOTE

For clusters running on platforms that are not machine API enabled, such as bare metal and other user-provisioned infrastructure, you must implement a method of automatically approving the kubelet serving certificate requests (CSRs). If a request is not approved, then the **oc exec**, **oc rsh**, and **oc logs** commands cannot succeed, because a serving certificate is required when the API server connects to the kubelet. Any operation that contacts the Kubelet endpoint requires this certificate approval to be in place. The method must watch for new CSRs, confirm that the CSR was submitted by the **node-bootstrapper** service account in the **system:node** or **system:admin** groups, and confirm the identity of the node.

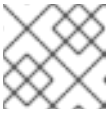
- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

1 **<csr_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{{"\n"}}
{{end}}{{end}}' | xargs --no-run-if-empty oc adm certificate approve
```



NOTE

Some Operators might not become available until some CSRs are approved.

4. Now that your client requests are approved, you must review the server requests for each machine that you added to the cluster:

```
$ oc get csr
```

Example output

```
NAME        AGE     REQUESTOR                                                   CONDITION
csr-bfd72   5m26s   system:node:ip-10-0-50-126.us-east-2.compute.internal
Pending
```

```
csr-c57lv   5m26s   system:node:ip-10-0-95-157.us-east-2.compute.internal
Pending
...
```

5. If the remaining CSRs are not approved, and are in the **Pending** status, approve the CSRs for your cluster machines:

   - To approve them individually, run the following command for each valid CSR:

     ```
     $ oc adm certificate approve <csr_name> 1
     ```

     1 **<csr_name>** is the name of a CSR from the list of current CSRs.

   - To approve all pending CSRs, run the following command:

     ```
     $ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{{"\n"}}
     {{end}}{{end}}' | xargs oc adm certificate approve
     ```

6. After all client and server CSRs have been approved, the machines have the **Ready** status. Verify this by running the following command:

   ```
   $ oc get nodes
   ```

   Example output

   ```
   NAME      STATUS    ROLES   AGE  VERSION
   master-0  Ready     master  73m  v1.24.0
   master-1  Ready     master  73m  v1.24.0
   master-2  Ready     master  74m  v1.24.0
   worker-0  Ready     worker  11m  v1.24.0
   worker-1  Ready     worker  11m  v1.24.0
   ```

NOTE

It can take a few minutes after approval of the server CSRs for the machines to transition to the **Ready** status.

Additional information

- For more information on CSRs, see Certificate Signing Requests.

21.6.22.1. Initial Operator configuration

After the control plane initializes, you must immediately configure some Operators so that they all become available.

Prerequisites

- Your control plane has initialized.

Procedure

1. Watch the cluster components come online:

```
$ watch -n5 oc get clusteroperators
```

Example output

```
NAME                                       VERSION   AVAILABLE   PROGRESSING   DEGRADED
SINCE
authentication                             4.11.0    True        False         False      19m
baremetal                                  4.11.0    True        False         False      37m
cloud-credential                           4.11.0    True        False         False      40m
cluster-autoscaler                         4.11.0    True        False         False      37m
config-operator                            4.11.0    True        False         False      38m
console                                    4.11.0    True        False         False      26m
csi-snapshot-controller                    4.11.0    True        False         False      37m
dns                                        4.11.0    True        False         False      37m
etcd                                       4.11.0    True        False         False      36m
image-registry                             4.11.0    True        False         False      31m
ingress                                    4.11.0    True        False         False      30m
insights                                   4.11.0    True        False         False      31m
kube-apiserver                             4.11.0    True        False         False      26m
kube-controller-manager                    4.11.0    True        False         False      36m
kube-scheduler                             4.11.0    True        False         False      36m
kube-storage-version-migrator              4.11.0    True        False         False      37m
machine-api                                4.11.0    True        False         False      29m
machine-approver                           4.11.0    True        False         False      37m
machine-config                             4.11.0    True        False         False      36m
marketplace                                4.11.0    True        False         False      37m
monitoring                                 4.11.0    True        False         False      29m
network                                    4.11.0    True        False         False      38m
node-tuning                                4.11.0    True        False         False      37m
openshift-apiserver                        4.11.0    True        False         False      32m
openshift-controller-manager               4.11.0    True        False         False      30m
openshift-samples                          4.11.0    True        False         False      32m
operator-lifecycle-manager                 4.11.0    True        False         False      37m
operator-lifecycle-manager-catalog         4.11.0    True        False         False      37m
operator-lifecycle-manager-packageserver   4.11.0    True        False         False      32m
service-ca                                 4.11.0    True        False         False      38m
storage                                    4.11.0    True        False         False      37m
```

2. Configure the Operators that are not available.

21.6.22.2. Image registry removed during installation

On platforms that do not provide shareable object storage, the OpenShift Image Registry Operator bootstraps itself as **Removed**. This allows **openshift-installer** to complete installations on these platform types.

After installation, you must edit the Image Registry Operator configuration to switch the **managementState** from **Removed** to **Managed**.

21.6.22.3. Image registry storage configuration

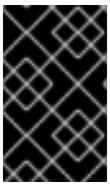
The Image Registry Operator is not initially available for platforms that do not provide default storage. After installation, you must configure your registry to use storage so that the Registry Operator is made available.

Instructions are shown for configuring a persistent volume, which is required for production clusters. Where applicable, instructions are shown for configuring an empty directory as the storage location, which is available for only non-production clusters.

Additional instructions are provided for allowing the image registry to use block storage types by using the **Recreate** rollout strategy during upgrades.

21.6.22.3.1. Configuring block registry storage for VMware vSphere

To allow the image registry to use block storage types such as vSphere Virtual Machine Disk (VMDK) during upgrades as a cluster administrator, you can use the **Recreate** rollout strategy.



IMPORTANT

Block storage volumes are supported but not recommended for use with image registry on production clusters. An installation where the registry is configured on block storage is not highly available because the registry cannot have more than one replica.

Procedure

1. Enter the following command to set the image registry storage as a block storage type, patch the registry so that it uses the **Recreate** rollout strategy, and runs with only **1** replica:

```
$ oc patch config.imageregistry.operator.openshift.io/cluster --type=merge -p '{"spec":
{"rolloutStrategy":"Recreate","replicas":1}}'
```

2. Provision the PV for the block storage device, and create a PVC for that volume. The requested block volume uses the ReadWriteOnce (RWO) access mode.

   a. Create a **pvc.yaml** file with the following contents to define a VMware vSphere **PersistentVolumeClaim** object:

```
kind: PersistentVolumeClaim
apiVersion: v1
metadata:
  name: image-registry-storage 1
  namespace: openshift-image-registry 2
spec:
  accessModes:
  - ReadWriteOnce 3
  resources:
    requests:
      storage: 100Gi 4
```

1. A unique name that represents the **PersistentVolumeClaim** object.
2. The namespace for the **PersistentVolumeClaim** object, which is **openshift-image-registry**.
3. The access mode of the persistent volume claim. With **ReadWriteOnce**, the volume can be mounted with read and write permissions by a single node.

4 The size of the persistent volume claim.

b. Enter the following command to create the **PersistentVolumeClaim** object from the file:

```
$ oc create -f pvc.yaml -n openshift-image-registry
```

3. Enter the following command to edit the registry configuration so that it references the correct PVC:

```
$ oc edit config.imageregistry.operator.openshift.io -o yaml
```

Example output

```
storage:
  pvc:
    claim: 1
```

1 By creating a custom PVC, you can leave the **claim** field blank for the default automatic creation of an **image-registry-storage** PVC.

For instructions about configuring registry storage so that it references the correct PVC, see Configuring the registry for vSphere.

21.6.23. Completing installation on user-provisioned infrastructure

After you complete the Operator configuration, you can finish installing the cluster on infrastructure that you provide.

Prerequisites

- Your control plane has initialized.
- You have completed the initial Operator configuration.

Procedure

1. Confirm that all the cluster components are online with the following command:

```
$ watch -n5 oc get clusteroperators
```

Example output

```
NAME                                       VERSION   AVAILABLE   PROGRESSING   DEGRADED
SINCE
authentication                             4.11.0    True        False         False      19m
baremetal                                  4.11.0    True        False         False      37m
cloud-credential                           4.11.0    True        False         False      40m
cluster-autoscaler                         4.11.0    True        False         False      37m
config-operator                            4.11.0    True        False         False      38m
console                                    4.11.0    True        False         False      26m
csi-snapshot-controller                    4.11.0    True        False         False      37m
```

```
dns                                        4.11.0    True        False         False      37m
etcd                                       4.11.0    True        False         False      36m
image-registry                             4.11.0    True        False         False      31m
ingress                                    4.11.0    True        False         False      30m
insights                                   4.11.0    True        False         False      31m
kube-apiserver                             4.11.0    True        False         False      26m
kube-controller-manager                    4.11.0    True        False         False      36m
kube-scheduler                             4.11.0    True        False         False      36m
kube-storage-version-migrator              4.11.0    True        False         False      37m
machine-api                                4.11.0    True        False         False      29m
machine-approver                           4.11.0    True        False         False      37m
machine-config                             4.11.0    True        False         False      36m
marketplace                                4.11.0    True        False         False      37m
monitoring                                 4.11.0    True        False         False      29m
network                                    4.11.0    True        False         False      38m
node-tuning                                4.11.0    True        False         False      37m
openshift-apiserver                        4.11.0    True        False         False      32m
openshift-controller-manager               4.11.0    True        False         False      30m
openshift-samples                          4.11.0    True        False         False      32m
operator-lifecycle-manager                 4.11.0    True        False         False      37m
operator-lifecycle-manager-catalog         4.11.0    True        False         False      37m
operator-lifecycle-manager-packageserver   4.11.0    True        False         False      32m
service-ca                                 4.11.0    True        False         False      38m
storage                                    4.11.0    True        False         False      37m
```

Alternatively, the following command notifies you when all of the clusters are available. It also retrieves and displays credentials:

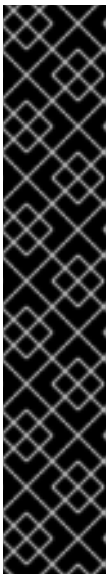
```
$ ./openshift-install --dir <installation_directory> wait-for install-complete 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

Example output

```
INFO Waiting up to 30m0s for the cluster to initialize...
```

The command succeeds when the Cluster Version Operator finishes deploying the OpenShift Container Platform cluster from Kubernetes API server.



IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

2. Confirm that the Kubernetes API server is communicating with the pods.

   a. To view a list of all pods, use the following command:

   ```
   $ oc get pods --all-namespaces
   ```

   Example output

   ```
   NAMESPACE                       NAME                                        READY   STATUS
   RESTARTS   AGE
   openshift-apiserver-operator    openshift-apiserver-operator-85cb746d55-zqhs8   1/1
   Running    1          9m
   openshift-apiserver             apiserver-67b9g                               1/1     Running     0
   3m
   openshift-apiserver             apiserver-ljcmx                               1/1     Running     0
   1m
   openshift-apiserver             apiserver-z25h4                               1/1     Running     0
   2m
   openshift-authentication-operator authentication-operator-69d5d8bf84-vh2n8        1/1
   Running    0          5m
   ...
   ```

   b. View the logs for a pod that is listed in the output of the previous command by using the following command:

   ```
   $ oc logs <pod_name> -n <namespace> 1
   ```

   1 Specify the pod name and namespace, as shown in the output of the previous command.

   If the pod logs display, the Kubernetes API server can communicate with the cluster machines.

3. For an installation with Fibre Channel Protocol (FCP), additional steps are required to enable multipathing. Do not enable multipathing during installation.
   See "Enabling multipathing with kernel arguments on RHCOS" in the *Post-installation machine configuration tasks* documentation for more information.

You can add extra compute machines after the cluster installation is completed by following Adding compute machines to vSphere.

21.6.24. Configuring vSphere DRS anti-affinity rules for control plane nodes

vSphere Distributed Resource Scheduler (DRS) anti-affinity rules can be configured to support higher availability of OpenShift Container Platform control plane nodes. Anti-affinity rules ensure that the vSphere Virtual Machines for the OpenShift Container Platform control plane nodes are not scheduled to the same vSphere Host.

IMPORTANT

- The following information applies to compute DRS only and does not apply to storage DRS.
- The **govc`** command is an open-source command available from VMware; it is not available from Red Hat. The **govc** command is not supported by the Red Hat support.
- Instructions for downloading and installing **govc** are found on the VMware documentation website.

Create an anti-affinity rule by running the following command:

Example command

```
$ govc cluster.rule.create \
  -name openshift4-control-plane-group \
  -dc MyDatacenter -cluster MyCluster \
  -enable \
  -anti-affinity master-0 master-1 master-2
```

After creating the rule, your control plane nodes are automatically migrated by vSphere so they are not running on the same hosts. This might take some time while vSphere reconciles the new rule. Successful command completion is shown in the following procedure.

NOTE

The migration occurs automatically and might cause brief OpenShift API outage or latency until the migration finishes.

The vSphere DRS anti-affinity rules need to be updated manually in the event of a control plane VM name change or migration to a new vSphere Cluster.

Procedure

1. Remove any existing DRS anti-affinity rule by running the following command:

```
$ govc cluster.rule.remove \
  -name openshift4-control-plane-group \
  -dc MyDatacenter -cluster MyCluster
```

Example Output

```
[13-10-22 09:33:24] Reconfigure /MyDatacenter/host/MyCluster...OK
```

2. Create the rule again with updated names by running the following command:

```
$ govc cluster.rule.create \
  -name openshift4-control-plane-group \
  -dc MyDatacenter -cluster MyOtherCluster \
  -enable \
  -anti-affinity master-0 master-1 master-2
```

21.6.25. Backing up VMware vSphere volumes

OpenShift Container Platform provisions new volumes as independent persistent disks to freely attach and detach the volume on any node in the cluster. As a consequence, it is not possible to back up volumes that use snapshots, or to restore volumes from snapshots. See Snapshot Limitations for more information.

Procedure

To create a backup of persistent volumes:

1. Stop the application that is using the persistent volume.
2. Clone the persistent volume.
3. Restart the application.
4. Create a backup of the cloned volume.
5. Delete the cloned volume.

21.6.26. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.11, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to OpenShift Cluster Manager Hybrid Cloud Console.

After you confirm that your OpenShift Cluster Manager Hybrid Cloud Console inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, use subscription watch to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

Additional resources

- See About remote health monitoring for more information about the Telemetry service

21.6.27. Next steps

- Customize your cluster.
- If necessary, you can opt out of remote health reporting .
- Set up your registry and configure registry storage .

- Optional: View the events from the vSphere Problem Detector Operator to determine if the cluster has permission or storage configuration issues.

21.7. INSTALLING A CLUSTER ON VSPHERE IN A RESTRICTED NETWORK

In OpenShift Container Platform 4.11, you can install a cluster on VMware vSphere infrastructure in a restricted network by creating an internal mirror of the installation release content.

NOTE

OpenShift Container Platform supports deploying a cluster to a single VMware vCenter only. Deploying a cluster with machines/machine sets on multiple vCenters is not supported.

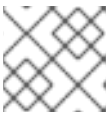
21.7.1. Prerequisites

- You reviewed details about the OpenShift Container Platform installation and update processes.
- You read the documentation on selecting a cluster installation method and preparing it for users.
- You created a registry on your mirror host and obtained the **imageContentSources** data for your version of OpenShift Container Platform.

IMPORTANT

Because the installation media is on the mirror host, you can use that computer to complete all installation steps.

- You provisioned persistent storage for your cluster. To deploy a private image registry, your storage must provide the ReadWriteMany access mode.
- The OpenShift Container Platform installer requires access to port 443 on the vCenter and ESXi hosts. You verified that port 443 is accessible.
- If you use a firewall, you confirmed with the administrator that port 443 is accessible. Control plane nodes must be able to reach vCenter and ESXi hosts on port 443 for the installation to succeed.
- If you use a firewall and plan to use the Telemetry service, you configured the firewall to allow the sites that your cluster requires access to.



NOTE

If you are configuring a proxy, be sure to also review this site list.

21.7.2. About installations in restricted networks

In OpenShift Container Platform 4.11, you can perform an installation that does not require an active connection to the internet to obtain software components. Restricted network installations can be completed using installer-provisioned infrastructure or user-provisioned infrastructure, depending on

the cloud platform to which you are installing the cluster.

If you choose to perform a restricted network installation on a cloud platform, you still require access to its cloud APIs. Some cloud functions, like Amazon Web Service's Route 53 DNS and IAM services, require internet access. Depending on your network, you might require less internet access for an installation on bare metal hardware or on VMware vSphere.

To complete a restricted network installation, you must create a registry that mirrors the contents of the OpenShift image registry and contains the installation media. You can create this registry on a mirror host, which can access both the internet and your closed network, or by using other methods that meet your restrictions.

21.7.2.1. Additional limits

Clusters in restricted networks have the following additional limitations and restrictions:

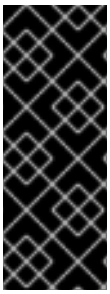
- The **ClusterVersion** status includes an **Unable to retrieve available updates** error.
- By default, you cannot use the contents of the Developer Catalog because you cannot access the required image stream tags.

21.7.3. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.11, you require access to the internet to obtain the images that are necessary to install your cluster.

You must have internet access to:

- Access OpenShift Cluster Manager Hybrid Cloud Console to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access Quay.io to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.



IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

21.7.4. VMware vSphere infrastructure requirements

You must install the OpenShift Container Platform cluster on a VMware vSphere version 7 instance that meets the requirements for the components that you use.

NOTE

OpenShift Container Platform version 4.11 does not support VMware vSphere version 8.0.

You can host the VMware vSphere infrastructure on-premise or on a VMware Cloud Verified provider that meets the requirements outlined in the following table:

Table 21.65. Version requirements for vSphere virtual environments

Virtual environment product	Required version
VM hardware version	15 or later
vSphere ESXi hosts	7
vCenter host	7

IMPORTANT

Installing a cluster on VMware vSphere version 7.0 Update 1 or earlier is now deprecated. These versions are still fully supported, but version 4.11 of OpenShift Container Platform requires vSphere virtual hardware version 15 or later. Hardware version 15 is now the default for vSphere virtual machines in OpenShift Container Platform. To update the hardware version for your vSphere nodes, see the "Updating hardware on nodes running in vSphere" article.

If your vSphere nodes are below hardware version 15 or your VMware vSphere version is earlier than 6.7.3, upgrading from OpenShift Container Platform 4.10 to OpenShift Container Platform 4.11 is not available.

Table 21.66. Minimum supported vSphere version for VMware components

Component	Minimum supported versions	Description
Hypervisor	vSphere 7 with HW version 15	This version is the minimum version that Red Hat Enterprise Linux CoreOS (RHCOS) supports. For more information about supported hardware on the latest version of Red Hat Enterprise Linux (RHEL) that is compatible with RHCOS, see Hardware on the Red Hat Customer Portal.
Storage with in-tree drivers	vSphere 7	This plugin creates vSphere storage by using the in-tree storage drivers for vSphere included in OpenShift Container Platform.

Component	Minimum supported versions	Description
Optional: Networking (NSX-T)	vSphere 7	vSphere 7 is required for OpenShift Container Platform. For more information about the compatibility of NSX and OpenShift Container Platform, see the Release Notes section of VMware's NSX container plugin documentation.

IMPORTANT

You must ensure that the time on your ESXi hosts is synchronized before you install OpenShift Container Platform. See Edit Time Configuration for a Host in the VMware documentation.

21.7.5. Network connectivity requirements

You must configure the network connectivity between machines to allow OpenShift Container Platform cluster components to communicate.

Review the following details about the required network ports.

Table 21.67. Ports used for all-machine to all-machine communications

Protocol	Port	Description
ICMP	N/A	Network reachability tests
TCP	**1936**	Metrics
	9000-**9999**	Host level services, including the node exporter on ports **9100**-**9101** and the Cluster Version Operator on port**9099**.
	10250-**10259**	The default ports that Kubernetes reserves
	10256	openshift-sdn
UDP	**4789**	virtual extensible LAN (VXLAN)
	6081	Geneve
	9000-**9999**	Host level services, including the node exporter on ports **9100**-**9101**.
	500	IPsec IKE packets
	4500	IPsec NAT-T packets

Protocol	Port	Description
TCP/UDP	**30000-32767**	Kubernetes node port
ESP	N/A	IPsec Encapsulating Security Payload (ESP)

Table 21.68. Ports used for all-machine to control plane communications

Protocol	Port	Description
TCP	**6443**	Kubernetes API

Table 21.69. Ports used for control plane machine to control plane machine communications

Protocol	Port	Description
TCP	**2379-2380**	etcd server and peer ports

21.7.6. VMware vSphere CSI Driver Operator requirements

To install the vSphere CSI Driver Operator, the following requirements must be met:

- VMware vSphere version 7.0 Update 1 or later
- Virtual machines of hardware version 15 or later
- No third-party vSphere CSI driver already installed in the cluster

IMPORTANT

If a third-party vSphere CSI driver is present in the cluster, OpenShift Container Platform does not overwrite it. If you continue with the third-party vSphere CSI driver when upgrading to the next major version of OpenShift Container Platform, the **oc** CLI prompts you with the following message:

> VSphereCSIDriverOperatorCRUpgradeable: VMwareVSphereControllerUpgradeable: found existing unsupported csi.vsphere.vmware.com driver

The previous message informs you that Red Hat does not support the third-party vSphere CSI driver during an OpenShift Container Platform upgrade operation. You can choose to ignore this message and continue with the upgrade operation.

Additional resources

- To remove a third-party vSphere CSI driver, see Removing a third-party vSphere CSI Driver .
- To update the hardware version for your vSphere nodes, see Updating hardware on nodes running in vSphere.

21.7.7. vCenter requirements

Before you install an OpenShift Container Platform cluster on your vCenter that uses infrastructure that the installer provisions, you must prepare your environment.

Required vCenter account privileges
To install an OpenShift Container Platform cluster in a vCenter, the installation program requires access to an account with privileges to read and create the required resources. Using an account that has global administrative privileges is the simplest way to access all of the necessary permissions.

If you cannot use an account with global administrative privileges, you must create roles to grant the privileges necessary for OpenShift Container Platform cluster installation. While most of the privileges are always required, some are required only if you plan for the installation program to provision a folder to contain the OpenShift Container Platform cluster on your vCenter instance, which is the default behavior. You must create or amend vSphere roles for the specified objects to grant the required privileges.

An additional role is required if the installation program is to create a vSphere virtual machine folder.

Example 21.16. Roles and privileges required for installation in vSphere API

vSphere object for role	When required	Required privileges in vSphere API
vSphere vCenter	Always	**Cns.Searchable** **InventoryService.Tagging.AttachTag** **InventoryService.Tagging.CreateCategory** **InventoryService.Tagging.CreateTag** **InventoryService.Tagging.DeleteCategory** **InventoryService.Tagging.DeleteTag** **InventoryService.Tagging.EditCategory** **InventoryService.Tagging.EditTag** **Sessions.ValidateSession** **StorageProfile.Update** **StorageProfile.View**
vSphere vCenter Cluster	If VMs will be created in the cluster root	**Host.Config.Storage** **Resource.AssignVMToPool** **VApp.AssignResourcePool** **VApp.Import** **VirtualMachine.Config.AddNewDisk**

vSphere object for role	When required	Required privileges in vSphere API
vSphere vCenter Resource Pool	If an existing resource pool is provided	**Host.Config.Storage** **Resource.AssignVMToPool** **VApp.AssignResourcePool** **VApp.Import** **VirtualMachine.Config.AddNewDisk**
vSphere Datastore	Always	**Datastore.AllocateSpace** **Datastore.Browse** **Datastore.FileManagement** **InventoryService.Tagging.ObjectAttachable**
vSphere Port Group	Always	**Network.Assign**
Virtual Machine Folder	Always	**InventoryService.Tagging.ObjectAttachable** **Resource.AssignVMToPool** **VApp.Import** **VirtualMachine.Config.AddExistingDisk** **VirtualMachine.Config.AddNewDisk** **VirtualMachine.Config.AddRemoveDevice** **VirtualMachine.Config.AdvancedConfig** **VirtualMachine.Config.Annotation** **VirtualMachine.Config.CPUCount** **VirtualMachine.Config.DiskExtend** **VirtualMachine.Config.DiskLease** **VirtualMachine.Config.EditDevice** **VirtualMachine.Config.Memory** **VirtualMachine.Config.RemoveDisk** **VirtualMachine.Config.Rename** **VirtualMachine.Config.ResetGuestInfo** **VirtualMachine.Config.Resource** **VirtualMachine.Config.Settings** **VirtualMachine.Config.UpgradeVirtualHardware**

vSphere object for role	When required	Required privileges in vSphere API
		VirtualMachine.Interact.GuestControl VirtualMachine.Interact.PowerOff VirtualMachine.Interact.PowerOn VirtualMachine.Interact.Reset VirtualMachine.Inventory.Create VirtualMachine.Inventory.CreateFromExisting VirtualMachine.Inventory.Delete VirtualMachine.Provisioning.Clone VirtualMachine.Provisioning.MarkAsTemplate VirtualMachine.Provisioning.DeployTemplate
vSphere vCenter Datacenter	If the installation program creates the virtual machine folder	InventoryService.Tagging.ObjectAttachable Resource.AssignVMToPool VApp.Import VirtualMachine.Config.AddExistingDisk VirtualMachine.Config.AddNewDisk VirtualMachine.Config.AddRemoveDevice VirtualMachine.Config.AdvancedConfig VirtualMachine.Config.Annotation VirtualMachine.Config.CPUCount VirtualMachine.Config.DiskExtend VirtualMachine.Config.DiskLease VirtualMachine.Config.EditDevice VirtualMachine.Config.Memory VirtualMachine.Config.RemoveDisk VirtualMachine.Config.Rename VirtualMachine.Config.ResetGuestInfo VirtualMachine.Config.Resource VirtualMachine.Config.Settings VirtualMachine.Config.Upgr

vSphere object for role	When required	Required privileges in vSphere API
		adeVirtualHardware VirtualMachine.Interact.DevicesControl VirtualMachine.Interact.PowerOff VirtualMachine.Interact.PowerOn VirtualMachine.Interact.Reset VirtualMachine.Inventory.Create VirtualMachine.Inventory.CreateFromExisting VirtualMachine.Inventory.Delete VirtualMachine.Provisioning.Clone VirtualMachine.Provisioning.DeployTemplate VirtualMachine.Provisioning.MarkAsTemplate Folder.Create Folder.Delete

Example 21.17. Roles and privileges required for installation in vCenter graphical user interface (GUI)

vSphere object for role	When required	Required privileges in vCenter GUI

vSphere object for role	When required	Required privileges in vCenter GUI
vSphere vCenter	Always	**Cns.Searchable "vSphere Tagging"."Assign or Unassign vSphere Tag" "vSphere Tagging"."Create vSphere Tag Category" "vSphere Tagging"."Create vSphere Tag" vSphere Tagging"."Delete vSphere Tag Category" "vSphere Tagging"."Delete vSphere Tag" "vSphere Tagging"."Edit vSphere Tag Category" "vSphere Tagging"."Edit vSphere Tag" Sessions."Validate session" "Profile-driven storage"."Profile-driven storage update" "Profile-driven storage"."Profile-driven storage view"**
vSphere vCenter Cluster	If VMs will be created in the cluster root	**Host.Configuration."Storage partition configuration" Resource."Assign virtual machine to resource pool" VApp."Assign resource pool" VApp.Import "Virtual machine"."Change Configuration"."Add new disk"**
vSphere vCenter Resource Pool	If an existing resource pool is provided	**Host.Configuration."Storage partition configuration" Resource."Assign virtual machine to resource pool" VApp."Assign resource pool" VApp.Import "Virtual machine"."Change Configuration"."Add new disk"**

vSphere object for role	When required	Required privileges in vCenter GUI
vSphere Datastore	Always	**Datastore."Allocate space" Datastore."Browse datastore" Datastore."Low level file operations" "vSphere Tagging"."Assign or Unassign vSphere Tag on Object"**
vSphere Port Group	Always	**Network."Assign network"**
Virtual Machine Folder	Always	**"vSphere Tagging"."Assign or Unassign vSphere Tag on Object" Resource."Assign virtual machine to resource pool" VApp.Import "Virtual machine"."Change Configuration"."Add existing disk" "Virtual machine"."Change Configuration"."Add new disk" "Virtual machine"."Change Configuration"."Add or remove device" "Virtual machine"."Change Configuration"."Advanced configuration" "Virtual machine"."Change Configuration"."Set annotation" "Virtual machine"."Change Configuration"."Change CPU count" "Virtual machine"."Change Configuration"."Extend virtual disk" "Virtual machine"."Change Configuration"."Acquire disk lease" "Virtual machine"."Change Configuration"."Modify device settings" "Virtual machine"."Change Configuration"."Change Memory" "Virtual machine"."Change Configuration"."Remove disk" "Virtual machine"."Change**

vSphere object for role	When required	Required privileges in vCenter GUI
		Configuration".Rename **Virtual machine"."Change Configuration"."Reset guest information"** **"Virtual machine"."Change Configuration"."Change resource"** **"Virtual machine"."Change Configuration"."Change Settings"** **"Virtual machine"."Change Configuration"."Upgrade virtual machine compatibility"** **"Virtual machine".Interaction."Guest operating system management by VIX API"** **"Virtual machine".Interaction."Power off"** **"Virtual machine".Interaction."Power on"** **"Virtual machine".Interaction.Reset** **"Virtual machine"."Edit Inventory"."Create new"** **"Virtual machine"."Edit Inventory"."Create from existing"** **"Virtual machine"."Edit Inventory"."Remove"** **"Virtual machine".Provisioning."Clone virtual machine"** **"Virtual machine".Provisioning."Mark as template"** **"Virtual machine".Provisioning."Deploy template"**
vSphere vCenter Datacenter	If the installation program creates the virtual machine folder	**"vSphere Tagging"."Assign or Unassign vSphere Tag on Object"** **Resource."Assign virtual machine to resource pool"** **VApp.Import** **"Virtual machine"."Change Configuration"."Add existing disk"** **"Virtual machine"."Change Configuration"."Add new disk"** **"Virtual machine"."Change**

vSphere object for role	When required	Required privileges in vCenter GUI
		Configuration"."Add or remove device "Virtual machine"."Change Configuration"."Advanced configuration" "Virtual machine"."Change Configuration"."Set annotation" "Virtual machine"."Change Configuration"."Change CPU count" "Virtual machine"."Change Configuration"."Extend virtual disk" "Virtual machine"."Change Configuration"."Acquire disk lease" "Virtual machine"."Change Configuration"."Modify device settings" "Virtual machine"."Change Configuration"."Change Memory" "Virtual machine"."Change Configuration"."Remove disk" "Virtual machine"."Change Configuration".Rename "Virtual machine"."Change Configuration"."Reset guest information" "Virtual machine"."Change Configuration"."Change resource" "Virtual machine"."Change Configuration"."Change Settings" "Virtual machine"."Change Configuration"."Upgrade virtual machine compatibility" "Virtual machine".Interaction."Guest operating system management by VIX API" "Virtual machine".Interaction."Power off" "Virtual machine".Interaction."Power on" "Virtual machine".Interaction.Reset "Virtual machine"."Edit Inventory"."Create new" "Virtual machine"."Edit

vSphere object for role	When required	Required privileges in vCenter GUI
		Inventory"."Create from existing" "Virtual machine"."Edit inventory"."Remove" "Virtual machine".Provisioning."Clone virtual machine" "Virtual machine".Provisioning."Deploy template" "Virtual machine".Provisioning."Mark as template" Folder."Create folder" Folder."Delete folder"

Additionally, the user requires some **ReadOnly** permissions, and some of the roles require permission to propogate the permissions to child objects. These settings vary depending on whether or not you install the cluster into an existing folder.

Example 21.18. Required permissions and propagation settings

vSphere object	When required	Propagate to children	Permissions required
vSphere vCenter	Always	False	Listed required privileges
vSphere vCenter Datacenter	Existing folder	False	**ReadOnly** permission
	Installation program creates the folder	True	Listed required privileges
vSphere vCenter Cluster	Existing resource pool	False	**ReadOnly** permission
	VMs in cluster root	True	Listed required privileges
vSphere vCenter Datastore	Always	False	Listed required privileges
vSphere Switch	Always	False	**ReadOnly** permission
vSphere Port Group	Always	False	Listed required privileges
vSphere vCenter Virtual Machine Folder	Existing folder	True	Listed required privileges

vSphere object	When required	Propagate to children	Permissions required
vSphere vCenter Resource Pool	Existing resource pool	True	Listed required privileges

For more information about creating an account with only the required privileges, see vSphere Permissions and User Management Tasks in the vSphere documentation.

Using OpenShift Container Platform with vMotion
If you intend on using vMotion in your vSphere environment, consider the following before installing a OpenShift Container Platform cluster.

- OpenShift Container Platform generally supports compute-only vMotion, where *generally* implies that you meet all VMware best practices for vMotion.
  To help ensure the uptime of your compute and control plane nodes, ensure that you follow the VMware best practices for vMotion, and use VMware anti-affinity rules to improve the availability of OpenShift Container Platform during maintenance or hardware issues.

  For more information about vMotion and anti-affinity rules, see the VMware vSphere documentation for vMotion networking requirements and VM anti-affinity rules.

- Using Storage vMotion can cause issues and is not supported. If you are using vSphere volumes in your pods, migrating a VM across datastores, either manually or through Storage vMotion, causes invalid references within OpenShift Container Platform persistent volume (PV) objects that can result in data loss.

- OpenShift Container Platform does not support selective migration of VMDKs across datastores, using datastore clusters for VM provisioning or for dynamic or static provisioning of PVs, or using a datastore that is part of a datastore cluster for dynamic or static provisioning of PVs.

Cluster resources
When you deploy an OpenShift Container Platform cluster that uses installer-provisioned infrastructure, the installation program must be able to create several resources in your vCenter instance.

A standard OpenShift Container Platform installation creates the following vCenter resources:

- 1 Folder
- 1 Tag category
- 1 Tag
- Virtual machines:
  - 1 template
  - 1 temporary bootstrap node
  - 3 control plane nodes
  - 3 compute machines

Although these resources use 856 GB of storage, the bootstrap node is destroyed during the cluster installation process. A minimum of 800 GB of storage is required to use a standard cluster.

If you deploy more compute machines, the OpenShift Container Platform cluster will use more storage.

Cluster limits
Available resources vary between clusters. The number of possible clusters within a vCenter is limited primarily by available storage space and any limitations on the number of required resources. Be sure to consider both limitations to the vCenter resources that the cluster creates and the resources that you require to deploy a cluster, such as IP addresses and networks.

Networking requirements
You must use the Dynamic Host Configuration Protocol (DHCP) for the network and ensure that the DHCP server is configured to provide persistent IP addresses to the cluster machines. In the DHCP lease, you must configure the DHCP to use the default gateway. All nodes must be in the same VLAN. You cannot scale the cluster using a second VLAN as a Day 2 operation. The VM in your restricted network must have access to vCenter so that it can provision and manage nodes, persistent volume claims (PVCs), and other resources. Additionally, you must create the following networking resources before you install the OpenShift Container Platform cluster:

NOTE

It is recommended that each OpenShift Container Platform node in the cluster must have access to a Network Time Protocol (NTP) server that is discoverable via DHCP. Installation is possible without an NTP server. However, asynchronous server clocks will cause errors, which NTP server prevents.

Required IP Addresses
An installer-provisioned vSphere installation requires two static IP addresses:

- The **API** address is used to access the cluster API.
- The **Ingress** address is used for cluster ingress traffic.

You must provide these IP addresses to the installation program when you install the OpenShift Container Platform cluster.

DNS records
You must create DNS records for two static IP addresses in the appropriate DNS server for the vCenter instance that hosts your OpenShift Container Platform cluster. In each record, **<cluster_name>** is the cluster name and **<base_domain>** is the cluster base domain that you specify when you install the cluster. A complete DNS record takes the form: **<component>.<cluster_name>.<base_domain>.**.

Table 21.70. Required DNS records

Component	Record	Description
API VIP	**api.<cluster_name>.<base_domain>.**	This DNS A/AAAA or CNAME record must point to the load balancer for the control plane machines. This record must be resolvable by both clients external to the cluster and from all the nodes within the cluster.

Component	Record	Description
Ingress VIP	***.apps.<cluster_name>.<base_domain>.**	A wildcard DNS A/AAAA or CNAME record that points to the load balancer that targets the machines that run the Ingress router pods, which are the worker nodes by default. This record must be resolvable by both clients external to the cluster and from all the nodes within the cluster.

21.7.8. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the **~/.ssh/authorized_keys** list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The **./openshift-install gather** command also requires the SSH public key to be in place on the cluster nodes.

IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.

NOTE

You must use a local key, not one that you configured with platform-specific approaches such as AWS key pairs.

Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N '' -f <path>/<file_name> 1
```

1. Specify the path and file name, such as **~/.ssh/id_ed25519**, of the new SSH key. If you have an existing key pair, ensure your public key is in the your **~/.ssh** directory.

NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS validated or Modules In Process cryptographic libraries on the **x86_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the ~/**.ssh/id_ed25519.pub** public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the **./openshift-install gather** command.

NOTE

On some distributions, default SSH private key identities such as ~/**.ssh/id_rsa** and ~/**.ssh/id_dsa** are managed automatically.

a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

Example output

```
Agent pid 31874
```

NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

1 Specify the path and file name for your SSH private key, such as ~/**.ssh/id_ed25519**

Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

21.7.9. Adding vCenter root CA certificates to your system trust

Because the installation program requires access to your vCenter's API, you must add your vCenter's trusted root CA certificates to your system trust before you install an OpenShift Container Platform cluster.

Procedure

1. From the vCenter home page, download the vCenter's root CA certificates. Click **Download trusted root CA certificates** in the vSphere Web Services SDK section. The **<vCenter>/certs/download.zip** file downloads.

2. Extract the compressed file that contains the vCenter root CA certificates. The contents of the compressed file resemble the following file structure:

```
certs
├── lin
│   ├── 108f4d17.0
│   ├── 108f4d17.r1
│   ├── 7e757f6a.0
│   ├── 8e4f8471.0
│   └── 8e4f8471.r0
├── mac
│   ├── 108f4d17.0
│   ├── 108f4d17.r1
│   ├── 7e757f6a.0
│   ├── 8e4f8471.0
│   └── 8e4f8471.r0
└── win
    ├── 108f4d17.0.crt
    ├── 108f4d17.r1.crl
    ├── 7e757f6a.0.crt
    ├── 8e4f8471.0.crt
    └── 8e4f8471.r0.crl

3 directories, 15 files
```

3. Add the files for your operating system to the system trust. For example, on a Fedora operating system, run the following command:

```
# cp certs/lin/* /etc/pki/ca-trust/source/anchors
```

4. Update your system trust. For example, on a Fedora operating system, run the following command:

```
# update-ca-trust extract
```

21.7.10. Creating the RHCOS image for restricted network installations

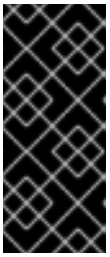
Download the Red Hat Enterprise Linux CoreOS (RHCOS) image to install OpenShift Container Platform on a restricted network VMware vSphere environment.

Prerequisites

- Obtain the OpenShift Container Platform installation program. For a restricted network installation, the program is on your mirror registry host.

Procedure

1. Log in to the Red Hat Customer Portal's Product Downloads page.
2. Under **Version**, select the most recent release of OpenShift Container Platform 4.11 for RHEL 8.



IMPORTANT

The RHCOS images might not change with every release of OpenShift Container Platform. You must download images with the highest version that is less than or equal to the OpenShift Container Platform version that you install. Use the image versions that match your OpenShift Container Platform version if they are available.

3. Download the **Red Hat Enterprise Linux CoreOS (RHCOS) - vSphere**image.
4. Upload the image you downloaded to a location that is accessible from the bastion server.

The image is now available for a restricted installation. Note the image name or location for use in OpenShift Container Platform deployment.

21.7.11. Creating the installation configuration file

You can customize the OpenShift Container Platform cluster you install on VMware vSphere.

Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster. For a restricted network installation, these files are on your mirror host.
- Have the **imageContentSources** values that were generated during mirror registry creation.
- Obtain the contents of the certificate for your mirror registry.
- Retrieve a Red Hat Enterprise Linux CoreOS (RHCOS) image and upload it to an accessible location.
- Obtain service principal permissions at the subscription level.

Procedure

1. Create the **install-config.yaml** file.
   a. Change to the directory that contains the installation program and run the following command:

```
$ ./openshift-install create install-config --dir <installation_directory> 1
```

1 For **<installation_directory>**, specify the directory name to store the files that the installation program creates.

When specifying the directory:

- Verify that the directory has the **execute** permission. This permission is required to run Terraform binaries under the installation directory.
- Use an empty directory. Some installation assets, such as bootstrap X.509 certificates, have short expiration intervals, therefore you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

b. At the prompts, provide the configuration details for your cloud:

i. Optional: Select an SSH key to use to access your cluster machines.

NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

ii. Select **vsphere** as the platform to target.

iii. Specify the name of your vCenter instance.

iv. Specify the user name and password for the vCenter account that has the required permissions to create the cluster.
The installation program connects to your vCenter instance.

v. Select the datacenter in your vCenter instance to connect to.

vi. Select the default vCenter datastore to use.

vii. Select the vCenter cluster to install the OpenShift Container Platform cluster in. The installation program uses the root resource pool of the vSphere cluster as the default resource pool.

viii. Select the network in the vCenter instance that contains the virtual IP addresses and DNS records that you configured.

ix. Enter the virtual IP address that you configured for control plane API access.

x. Enter the virtual IP address that you configured for cluster ingress.

xi. Enter the base domain. This base domain must be the same one that you used in the DNS records that you configured.

xii. Enter a descriptive name for your cluster. The cluster name you enter must match the cluster name you specified when configuring the DNS records.

xiii. Paste the pull secret from the Red Hat OpenShift Cluster Manager .

2. In the **install-config.yaml** file, set the value of **platform.vsphere.clusterOSImage** to the image location or name. For example:

```
platform:
  vsphere:
    clusterOSImage: http://mirror.example.com/images/rhcos-43.81.201912131630.0-
vmware.x86_64.ova?
sha256=ffebbd68e8a1f2a245ca19522c16c86f67f9ac8e4e0c1f0a812b068b16f7265d
```

3. Edit the **install-config.yaml** file to give the additional information that is required for an installation in a restricted network.

   a. Update the **pullSecret** value to contain the authentication information for your registry:

   ```
   pullSecret: '{"auths":{"<mirror_host_name>:5000": {"auth": "<credentials>","email":
   "you@example.com"}}}'
   ```

   For **<mirror_host_name>**, specify the registry domain name that you specified in the certificate for your mirror registry, and for **<credentials>**, specify the base64-encoded user name and password for your mirror registry.

   b. Add the **additionalTrustBundle** parameter and value.

   ```
   additionalTrustBundle: |
     -----BEGIN CERTIFICATE-----

   ZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZ
     -----END CERTIFICATE-----
   ```

   The value must be the contents of the certificate file that you used for your mirror registry. The certificate file can be an existing, trusted certificate authority, or the self-signed certificate that you generated for the mirror registry.

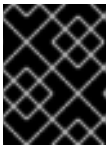
   c. Add the image content resources, which resemble the following YAML excerpt:

   ```
   imageContentSources:
   - mirrors:
     - <mirror_host_name>:5000/<repo_name>/release
     source: quay.io/openshift-release-dev/ocp-release
   - mirrors:
     - <mirror_host_name>:5000/<repo_name>/release
     source: registry.redhat.io/ocp/release
   ```

   For these values, use the **imageContentSources** that you recorded during mirror registry creation.

4. Make any other modifications to the **install-config.yaml** file that you require. You can find more information about the available parameters in the **Installation configuration parameters** section.

5. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.

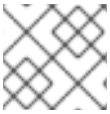


IMPORTANT

The **install-config.yaml** file is consumed during the installation process. If you want to reuse the file, you must back it up now.

21.7.11.1. Installation configuration parameters

Before you deploy an OpenShift Container Platform cluster, you provide parameter values to describe your account on the cloud platform that hosts your cluster and optionally customize your cluster's platform. When you create the **install-config.yaml** installation configuration file, you provide values for the required parameters through the command line. If you customize your cluster, you can modify the **install-config.yaml** file to provide more details about the platform.



NOTE

After installation, you cannot modify these parameters in the **install-config.yaml** file.

21.7.11.1.1. Required configuration parameters

Required installation configuration parameters are described in the following table:

Table 21.71. Required parameters

Parameter	Description	Values
apiVersion	The API version for the **install-config.yaml** content. The current version is **v1**. The installer may also support older API versions.	String
baseDomain	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the **baseDomain** and **metadata.name** parameter values that uses the **<metadata.name>.<baseDomain>** format.	A fully-qualified domain or subdomain name, such as **example.com**.
metadata	Kubernetes resource **ObjectMeta**, from which only the **name** parameter is consumed.	Object
metadata.name	The name of the cluster. DNS records for the cluster are all subdomains of **{{.metadata.name}}.{{.baseDomain}}**.	String of lowercase letters and hyphens (**-**), such as **dev**.

Parameter	Description	Values
platform	The configuration for the specific platform upon which to perform the installation: **alibabacloud**, **aws**, **baremetal**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**. For additional information about **platform.<platform>** parameters, consult the table for your specific platform that follows.	Object
pullSecret	Get a pull secret from the Red Hat OpenShift Cluster Manager to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	<pre>{ "auths":{ "cloud.openshift.com":{ "auth":"b3Blb=", "email":"you@example.com" }, "quay.io":{ "auth":"b3Blb=", "email":"you@example.com" } } }</pre>

21.7.11.1.2. Network configuration parameters

You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

Only IPv4 addresses are supported.

NOTE

Globalnet is not supported with Red Hat OpenShift Data Foundation disaster recovery solutions. For regional disaster recovery scenarios, ensure that you use a nonoverlapping range of private IP addresses for the cluster and service networks in each cluster.

Table 21.72. Network parameters

Parameter	Description	Values

Parameter	Description	Values
networking	The configuration for the cluster network.	Object  **NOTE** You cannot modify parameters specified by the **networking** object after installation.
networking.networkType	The cluster network provider Container Network Interface (CNI) cluster network provider to install.	Either **OpenShiftSDN** or **OVNKubernetes**. **OpenShiftSDN** is a CNI provider for all-Linux networks. **OVNKubernetes** is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is **OpenShiftSDN**.
networking.clusterNetwork	The IP address blocks for pods. The default value is **10.128.0.0/14** with a host prefix of **/23**. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: `networking:` `  clusterNetwork:` `  - cidr: 10.128.0.0/14` `    hostPrefix: 23`
networking.clusterNetwork.cidr	Required if you use **networking.clusterNetwork**. An IP address block. An IPv4 network.	An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between **0** and **32**.
networking.clusterNetwork.hostPrefix	The subnet prefix length to assign to each individual node. For example, if **hostPrefix** is set to **23** then each node is assigned a **/23** subnet out of the given **cidr**. A **hostPrefix** value of **23** provides 510 (2^(32 - 23) - 2) pod IP addresses.	A subnet prefix. The default value is **23**.
networking.serviceNetwork	The IP address block for services. The default value is **172.30.0.0/16**. The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.	An array with an IP address block in CIDR format. For example: `networking:` `  serviceNetwork:` `  - 172.30.0.0/16`

Parameter	Description	Values
networking.machineNetwork	The IP address blocks for machines. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: `networking:` `  machineNetwork:` `  - cidr: 10.0.0.0/16`
networking.machineNetwork.cidr	Required if you use **networking.machineNetwork**. An IP address block. The default value is **10.0.0.0/16** for all platforms other than libvirt. For libvirt, the default value is **192.168.126.0/24**.	An IP network block in CIDR notation. For example, **10.0.0.0/16**. **NOTE** Set the **networking.machineNetwork** to match the CIDR that the preferred NIC resides in.

21.7.11.1.3. Optional configuration parameters

Optional installation configuration parameters are described in the following table:

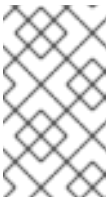
Table 21.73. Optional parameters

Parameter	Description	Values
additionalTrustBundle	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String
capabilities	Controls the installation of optional core cluster components. You can reduce the footprint of your OpenShift Container Platform cluster by disabling optional components.	String array

Parameter	Description	Values
capabilities.baselineCapabilitySet	Selects an initial set of optional capabilities to enable. Valid values are **None**, **v4.11** and **vCurrent**. **v4.11** enables the **baremetal** Operator, the **marketplace** Operator, and the **openshift-samples** content. **vCurrent** installs the recommended set of capabilities for the current version of OpenShift Container Platform. The default value is **vCurrent**.	String
capabilities.additionalEnabledCapabilities	Extends the set of optional capabilities beyond what you specify in **baselineCapabilitySet**. Valid values are **baremetal**, **marketplace** and **openshift-samples**. You may specify multiple capabilities in this parameter.	String array
cgroupsV2	Enables Linux control groups version 2 (cgroups v2) on specific nodes in your cluster. The OpenShift Container Platform process for enabling cgroups v2 disables all cgroup version 1 controllers and hierarchies. The OpenShift Container Platform cgroups version 2 feature is in Developer Preview and is not supported by Red Hat at this time.	**true**
compute	The configuration for the machines that comprise the compute nodes.	Array of **MachinePool** objects.
compute.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** (the default).	String
compute.name	Required if you use **compute**. The name of the machine pool.	**worker**
compute.platform	Required if you use **compute**. Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the **controlPlane.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**

Parameter	Description	Values
compute.replicas	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to **2**. The default value is **3**.
controlPlane	The configuration for the machines that comprise the control plane.	Array of **MachinePool** objects.
controlPlane.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** (the default).	String
controlPlane.name	Required if you use **controlPlane**. The name of the machine pool.	**master**
controlPlane.platform	Required if you use **controlPlane**. Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the **compute.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
controlPlane.replicas	The number of control plane machines to provision.	The only supported value is **3**, which is the default value.

Parameter	Description	Values
credentialsMode	The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported.  **NOTE** Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the *Cloud Credential Operator* entry in the *Cluster Operators reference* content.  **NOTE** If your AWS account has service control policies (SCP) enabled, you must configure the **credentialsMode** parameter to **Mint**, **Passthrough** or **Manual**.	**Mint**, **Passthrough**, **Manual** or an empty string (**""**).

Parameter	Description	Values
fips	Enable or disable FIPS mode. The default is **false** (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.  **IMPORTANT** To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.  **NOTE** If you are using Azure File storage, you cannot enable FIPS mode.	**false** or **true**
imageContentSources	Sources and repositories for the release-image content.	Array of objects. Includes a **source** and, optionally, **mirrors**, as described in the following rows of this table.
imageContentSources.source	Required if you use **imageContentSources**. Specify the repository that users refer to, for example, in image pull specifications.	String
imageContentSources.mirrors	Specify one or more repositories that may also contain the same images.	Array of strings

Parameter	Description	Values
publish	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	**Internal** or **External**. The default value is **External**. Setting this field to **Internal** is not supported on non-cloud platforms and IBM Cloud VPC.  **IMPORTANT** If the value of the field is set to **Internal**, the cluster will become non-functional. For more information, refer to BZ#1953035.
sshKey	The SSH key to authenticate access to your cluster machines.  **NOTE** For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.	For example, **sshKey: ssh-ed25519 AAAA..**.

21.7.11.1.4. Additional VMware vSphere configuration parameters

Additional VMware vSphere configuration parameters are described in the following table:

Table 21.74. Additional VMware vSphere cluster parameters

Parameter	Description	Values
platform: vsphere vCenter	The fully-qualified hostname or IP address of the vCenter server.	String

Parameter	Description	Values
platform: vsphere username	The user name to use to connect to the vCenter instance with. This user must have at least the roles and privileges that are required for static or dynamic persistent volume provisioning in vSphere.	String
platform: vsphere password	The password for the vCenter user name.	String
platform: vsphere datacenter	The name of the datacenter to use in the vCenter instance.	String
platform: vsphere defaultDatastore	The name of the default datastore to use for provisioning volumes.	String
platform: vsphere folder	Optional. The absolute path of an existing folder where the installation program creates the virtual machines. If you do not provide this value, the installation program creates a folder that is named with the infrastructure ID in the datacenter virtual machine folder.	String, for example, **/<datacenter_name>/vm/<folder_name>/<subfolder_name>**.
platform: vsphere resourcePool	Optional. The absolute path of an existing resource pool where the installer creates the virtual machines. If you do not specify a value, resources are installed in the root of the cluster **/<datacenter_name>/host/<cluster_name>/Resources**.	String, for example, **/<datacenter_name>/host/<cluster_name>/Resources/<resource_pool_name>/<optional_nested_resource_pool_name>**.
platform: vsphere network	The network in the vCenter instance that contains the virtual IP addresses and DNS records that you configured.	String
platform: vsphere cluster	The vCenter cluster to install the OpenShift Container Platform cluster in.	String

Parameter	Description	Values
platform: vsphere apiVIP	The virtual IP (VIP) address that you configured for control plane API access.	An IP address, for example **128.0.0.1**.
platform: vsphere ingressVIP	The virtual IP (VIP) address that you configured for cluster ingress.	An IP address, for example **128.0.0.1**.
platform: vsphere diskType	Optional. The disk provisioning method. This value defaults to the vSphere default storage policy if not set.	Valid values are **thin**, **thick**, or **eagerZeroedThick**.

21.7.11.1.5. Optional VMware vSphere machine pool configuration parameters

Optional VMware vSphere machine pool configuration parameters are described in the following table:

Table 21.75. Optional VMware vSphere machine pool parameters

Parameter	Description	Values
platform: vsphere clusterOSImage	The location from which the installer downloads the RHCOS image. You must set this parameter to perform an installation in a restricted network.	An HTTP or HTTPS URL, optionally with a SHA-256 checksum. For example, **https://mirror.openshift.com/images/rhcos-<version>-vmware.<architecture>.ova**.
platform vsphere osDisk diskSizeGB	The size of the disk in gigabytes.	Integer
platform vsphere cpus	The total number of virtual processor cores to assign a virtual machine. The value of **platform.vsphere.cpus** must be a multiple of **platform.vsphere.coresPerSocket** value.	Integer

Parameter	Description	Values
platform vsphere coresPerSocket	The number of cores per socket in a virtual machine. The number of virtual sockets on the virtual machine is **platform.vsphere.cpus/platform.vsphere.coresPerSocket**. The default value for control plane nodes and worker nodes is **4** and **2**, respectively.	Integer
platform vsphere memoryMB	The size of a virtual machine's memory in megabytes.	Integer

21.7.11.2. Sample install-config.yaml file for an installer-provisioned VMware vSphere cluster

You can customize the install-config.yaml file to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.

```
apiVersion: v1
baseDomain: example.com (1)
compute: (2)
  name: worker
  replicas: 3
  platform:
    vsphere: (3)
      cpus: 2
      coresPerSocket: 2
      memoryMB: 8192
      osDisk:
        diskSizeGB: 120
controlPlane: (4)
  name: master
  replicas: 3
  platform:
    vsphere: (5)
      cpus: 4
      coresPerSocket: 2
      memoryMB: 16384
      osDisk:
        diskSizeGB: 120
metadata:
  name: cluster (6)
platform:
  vsphere:
    vcenter: your.vcenter.server
    username: username
    password: password
```

```
    datacenter: datacenter
    defaultDatastore: datastore
    folder: folder
    resourcePool: resource_pool (7)
    diskType: thin (8)
    network: VM_Network
    cluster: vsphere_cluster_name (9)
    apiVIP: api_vip
    ingressVIP: ingress_vip
    clusterOSImage: http://mirror.example.com/images/rhcos-47.83.202103221318-0-
vmware.x86_64.ova (10)
fips: false
pullSecret: '{"auths":{"<local_registry>": {"auth": "<credentials>","email": "you@example.com"}}}' (11)
sshKey: 'ssh-ed25519 AAAA...'
additionalTrustBundle: | (12)
  -----BEGIN CERTIFICATE-----
  ZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZ
  -----END CERTIFICATE-----
imageContentSources: (13)
- mirrors:
  - <mirror_host_name>:<mirror_port>/<repo_name>/release
  source: <source_image_1>
- mirrors:
  - <mirror_host_name>:<mirror_port>/<repo_name>/release-images
  source: <source_image_2>
```

(1) The base domain of the cluster. All DNS records must be sub-domains of this base and include the cluster name.

(2) (4) The **controlPlane** section is a single mapping, but the **compute** section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, **-**, and the first line of the **controlPlane** section must not. Only one control plane pool is used.

(3) (5) Optional: Provide additional configuration for the machine pool parameters for the compute and control plane machines.

(6) The cluster name that you specified in your DNS records.

(7) Optional: Provide an existing resource pool for machine creation. If you do not specify a value, the installation program uses the root resource pool of the vSphere cluster.

(8) The vSphere disk provisioning method.

(9) The vSphere cluster to install the OpenShift Container Platform cluster in.

(10) The location of the Red Hat Enterprise Linux CoreOS (RHCOS) image that is accessible from the bastion server.

(11) For **<local_registry>**, specify the registry domain name, and optionally the port, that your mirror registry uses to serve content. For example **registry.example.com** or **registry.example.com:5000**. For **<credentials>**, specify the base64-encoded user name and password for your mirror registry.

(12) Provide the contents of the certificate file that you used for your mirror registry.

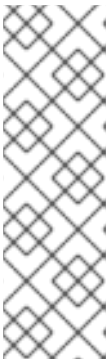
13 Provide the **imageContentSources** section from the output of the command to mirror the repository.

21.7.11.3. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.



NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
```

1 A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.

2 A proxy URL to use for creating HTTPS connections outside the cluster.

3 A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use * to bypass the proxy for all destinations. You must include vCenter's IP address and the IP range that you use for its machines.

4 If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace that contains one or more additional CA certificates

NOTE

The installation program does not support the proxy **readinessEndpoints** field.

NOTE

If the installer times out, restart and then complete the deployment by using the **wait-for** command of the installer. For example:

```
$ ./openshift-install wait-for install-complete --log-level debug
```

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.

NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

21.7.12. Deploying the cluster

You can install OpenShift Container Platform on a compatible cloud platform.

IMPORTANT

You can run the **create cluster** command of the installation program only once, during initial installation.

Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.

Procedure

- Change to the directory that contains the installation program and initialize the cluster deployment:

```
$ ./openshift-install create cluster --dir <installation_directory> \ 1
    --log-level=info 2
```

1 For **<installation_directory>**, specify the location of your customized **./install-config.yaml** file.

2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

Verification

When the cluster deployment completes successfully:

- The terminal displays directions for accessing your cluster, including a link to the web console and credentials for the **kubeadmin** user.
- Credential information also outputs to **<installation_directory>/.openshift_install.log**.

IMPORTANT

Do not delete the installation program or the files that the installation program creates. Both are required to delete the cluster.

Example output

```
...
INFO Install complete!
INFO To access the cluster as the system:admin user when using 'oc', run 'export
KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
INFO Access the OpenShift web-console here: https://console-openshift-
console.apps.mycluster.example.com
INFO Login to the console with user: "kubeadmin", and password: "password"
INFO Time elapsed: 36m22s
```

IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

21.7.13. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.

IMPORTANT

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.11. Download and install the new version of **oc**.

Installing the OpenShift CLI on Linux

You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the architecture in the **Product Variant** drop-down menu.
3. Select the appropriate version in the **Version** drop-down menu.
4. Click **Download Now** next to the **OpenShift v4.11 Linux Client** entry and save the file.
5. Unpack the archive:

```
$ tar xvf <file>
```

6. Place the **oc** binary in a directory that is on your **PATH**.
   To check your **PATH**, execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.
   To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
C:\> oc <command>
```

Installing the OpenShift CLI on macOS

You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 macOS Client** entry and save the file.

NOTE

For macOS arm64, choose the **OpenShift v4.11 macOS arm64 Client** entry.

4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your PATH.
   To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

21.7.14. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

Example output

```
system:admin
```

21.7.15. Disabling the default OperatorHub sources

Operator catalogs that source content provided by Red Hat and community projects are configured for OperatorHub by default during an OpenShift Container Platform installation. In a restricted network environment, you must disable the default catalogs as a cluster administrator.

Procedure

- Disable the sources for the default catalogs by adding **disableAllDefaultSources: true** to the **OperatorHub** object:

```
$ oc patch OperatorHub cluster --type json \
    -p '[{"op": "add", "path": "/spec/disableAllDefaultSources", "value": true}]'
```

TIP

Alternatively, you can use the web console to manage catalog sources. From the **Administration → Cluster Settings → Configuration → OperatorHub** page, click the **Sources** tab, where you can create, update, delete, disable, and enable individual sources.

21.7.16. Creating registry storage

After you install the cluster, you must create storage for the Registry Operator.

21.7.16.1. Image registry removed during installation

On platforms that do not provide shareable object storage, the OpenShift Image Registry Operator bootstraps itself as **Removed**. This allows **openshift-installer** to complete installations on these platform types.

After installation, you must edit the Image Registry Operator configuration to switch the **managementState** from **Removed** to **Managed**.

21.7.16.2. Image registry storage configuration

The Image Registry Operator is not initially available for platforms that do not provide default storage. After installation, you must configure your registry to use storage so that the Registry Operator is made available.

Instructions are shown for configuring a persistent volume, which is required for production clusters. Where applicable, instructions are shown for configuring an empty directory as the storage location, which is available for only non-production clusters.

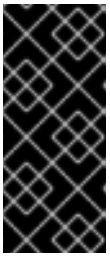
Additional instructions are provided for allowing the image registry to use block storage types by using the **Recreate** rollout strategy during upgrades.

21.7.16.2.1. Configuring registry storage for VMware vSphere

As a cluster administrator, following installation you must configure your registry to use storage.

Prerequisites

- Cluster administrator permissions.
- A cluster on VMware vSphere.
- Persistent storage provisioned for your cluster, such as Red Hat OpenShift Data Foundation.



IMPORTANT

OpenShift Container Platform supports **ReadWriteOnce** access for image registry storage when you have only one replica. **ReadWriteOnce** access also requires that the registry uses the **Recreate** rollout strategy. To deploy an image registry that supports high availability with two or more replicas, **ReadWriteMany** access is required.

- Must have "100Gi" capacity.

IMPORTANT

Testing shows issues with using the NFS server on RHEL as storage backend for core services. This includes the OpenShift Container Registry and Quay, Prometheus for monitoring storage, and Elasticsearch for logging storage. Therefore, using RHEL NFS to back PVs used by core services is not recommended.

Other NFS implementations on the marketplace might not have these issues. Contact the individual NFS implementation vendor for more information on any testing that was possibly completed against these OpenShift Container Platform core components.

Procedure

1. To configure your registry to use storage, change the **spec.storage.pvc** in the **configs.imageregistry/cluster** resource.

NOTE

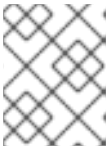
When you use shared storage, review your security settings to prevent outside access.

2. Verify that you do not have a registry pod:

```
$ oc get pod -n openshift-image-registry -l docker-registry=default
```

Example output

```
No resourses found in openshift-image-registry namespace
```



NOTE

If you do have a registry pod in your output, you do not need to continue with this procedure.

3. Check the registry configuration:

```
$ oc edit configs.imageregistry.operator.openshift.io
```

Example output

```
storage:
  pvc:
    claim: 1
```

1 Leave the **claim** field blank to allow the automatic creation of an **image-registry-storage** persistent volume claim (PVC). The PVC is generated based on the default storage class. However, be aware that the default storage class might provide ReadWriteOnce (RWO) volumes, such as a RADOS Block Device (RBD), which can cause issues when you replicate to more than one replica.

4. Check the **clusteroperator** status:

```
$ oc get clusteroperator image-registry
```

Example output

```
NAME             VERSION                             AVAILABLE   PROGRESSING   DEGRADED
SINCE   MESSAGE
image-registry   4.7                                 True        False         False     6h50m
```

21.7.17. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.11, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to OpenShift Cluster Manager Hybrid Cloud Console.

After you confirm that your OpenShift Cluster Manager Hybrid Cloud Console inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, use subscription watch to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

Additional resources

- See About remote health monitoring for more information about the Telemetry service

21.7.18. Configuring an external load balancer

You can configure an OpenShift Container Platform cluster to use an external load balancer in place of the default load balancer.

IMPORTANT

Configuring an external load balancer depends on your vendor's load balancer.

The information and examples in this section are for guideline purposes only. Consult the vendor documentation for more specific information about the vendor's load balancer.

Red Hat supports the following services for an external load balancer:

- Ingress Controller
- OpenShift API
- OpenShift MachineConfig API

You can choose whether you want to configure one or all of these services for an external load balancer. Configuring only the Ingress Controller service is a common configuration option. To better understand each service, view the following diagrams:

Figure 21.10. Example network workflow that shows an Ingress Controller operating in an OpenShift Container Platform environment

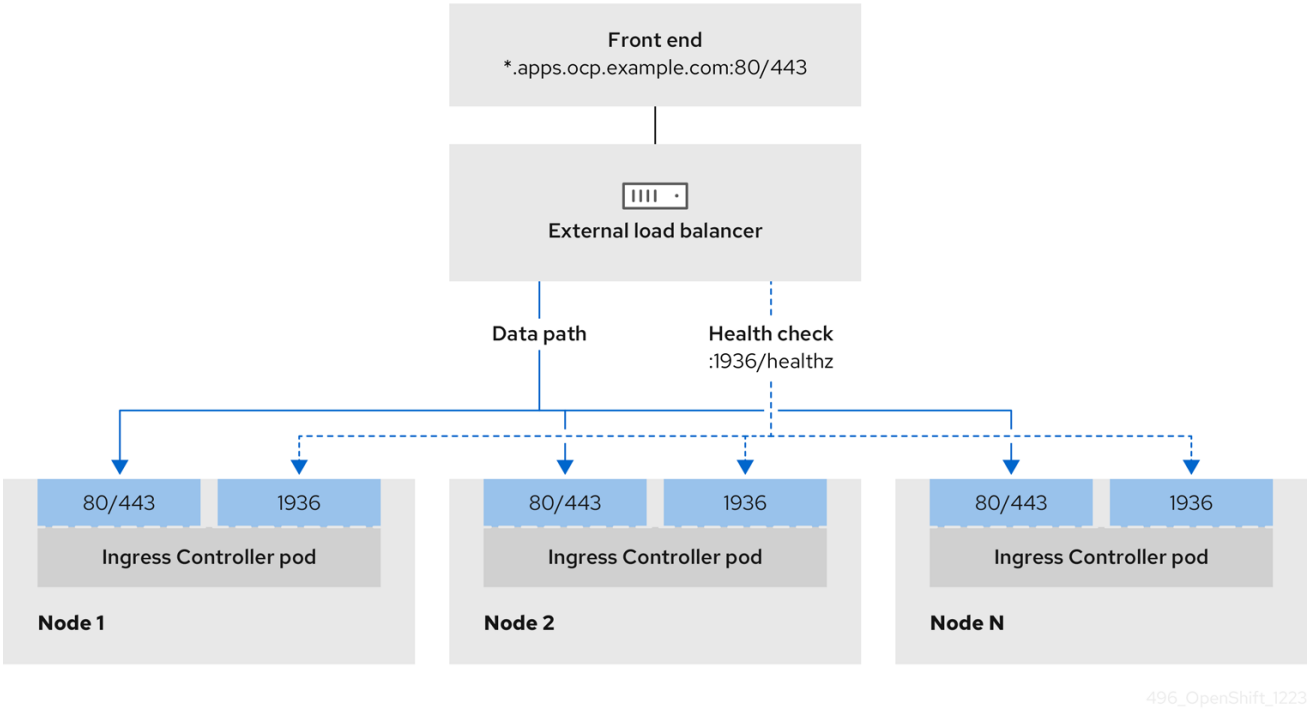


Figure 21.11. Example network workflow that shows an OpenShift API operating in an OpenShift Container Platform environment

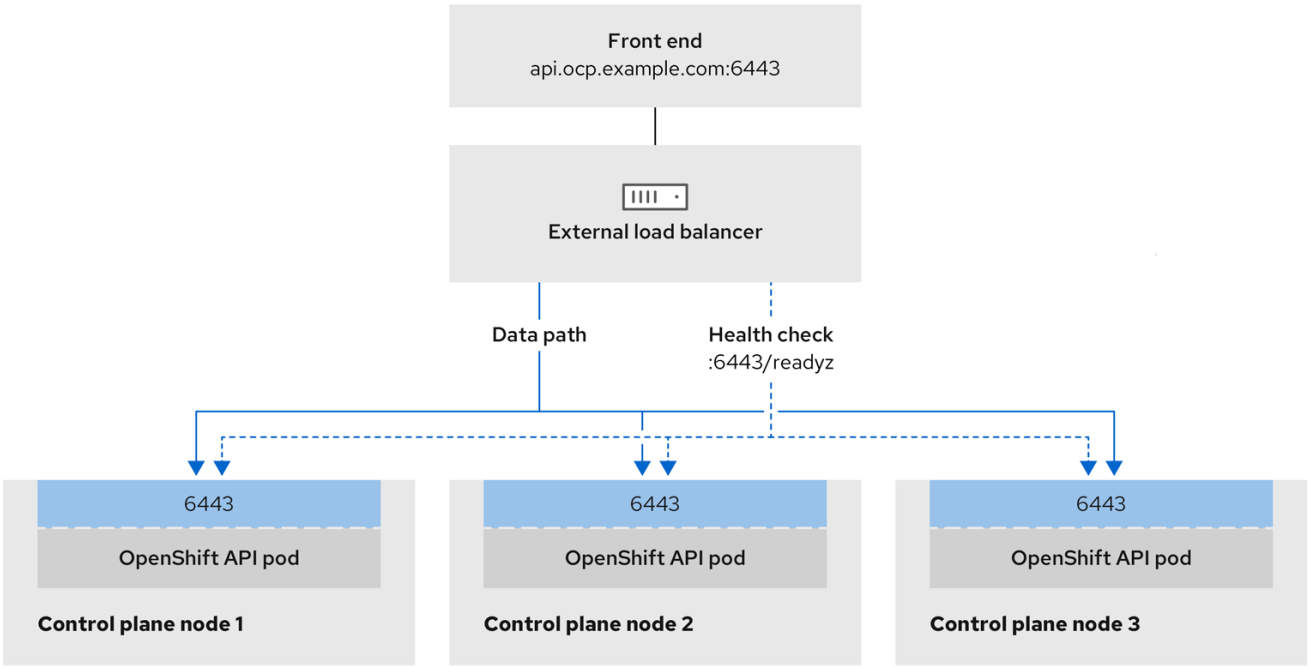
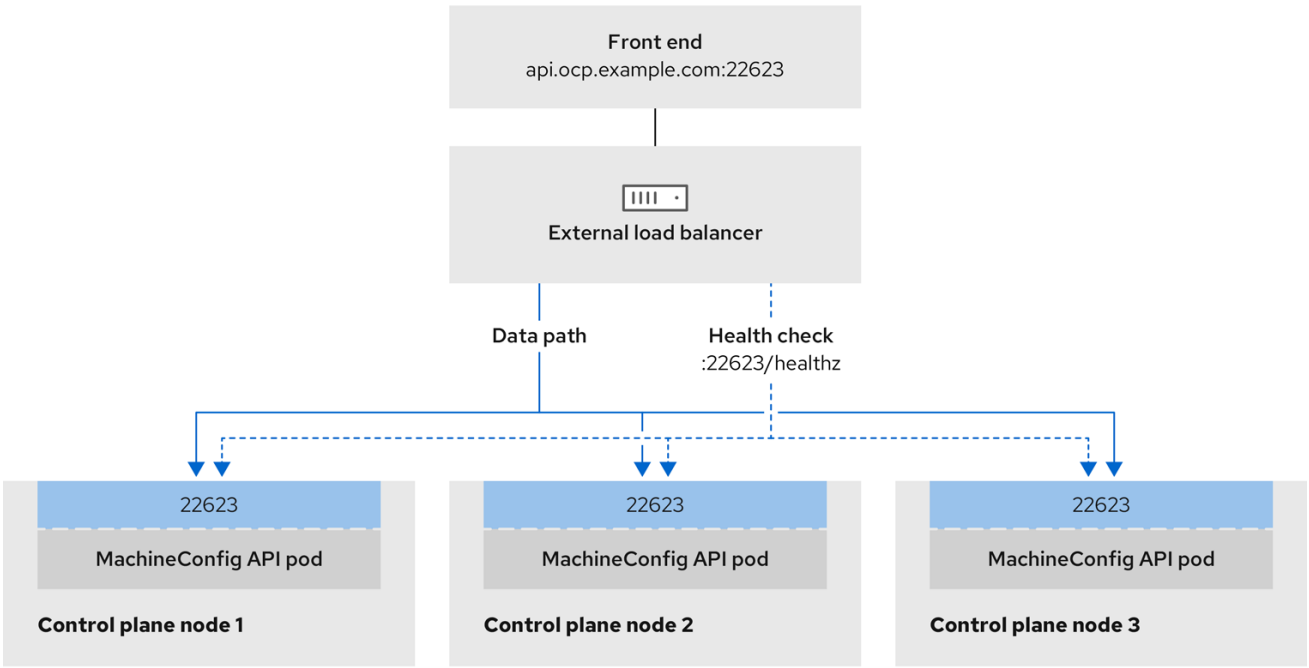


Figure 21.12. Example network workflow that shows an OpenShift MachineConfig API operating in an OpenShift Container Platform environment



Considerations

- For a front-end IP address, you can use the same IP address for the front-end IP address, the Ingress Controller's load balancer, and API load balancer. Check the vendor's documentation for this capability.

- For a back-end IP address, ensure that an IP address for an OpenShift Container Platform control plane node does not change during the lifetime of the external load balancer. You can achieve this by completing one of the following actions:
    - Assign a static IP address to each control plane node.
    - Configure each node to receive the same IP address from the DHCP every time the node requests a DHCP lease. Depending on the vendor, the DHCP lease might be in the form of an IP reservation or a static DHCP assignment.
- Manually define each node that runs the Ingress Controller in the external load balancer for the Ingress Controller back-end service. For example, if the Ingress Controller moves to an undefined node, a connection outage can occur.

OpenShift API prerequisites

- You defined a front-end IP address.
- TCP ports 6443 and 22623 are exposed on the front-end IP address of your load balancer. Check the following items:
    - Port 6443 provides access to the OpenShift API service.
    - Port 22623 can provide ignition startup configurations to nodes.
- The front-end IP address and port 6443 are reachable by all users of your system with a location external to your OpenShift Container Platform cluster.
- The front-end IP address and port 22623 are reachable only by OpenShift Container Platform nodes.
- The load balancer backend can communicate with OpenShift Container Platform control plane nodes on port 6443 and 22623.

Ingress Controller prerequisites

- You defined a front-end IP address.
- TCP ports 443 and 80 are exposed on the front-end IP address of your load balancer.
- The front-end IP address, port 80 and port 443 are be reachable by all users of your system with a location external to your OpenShift Container Platform cluster.
- The front-end IP address, port 80 and port 443 are reachable to all nodes that operate in your OpenShift Container Platform cluster.
- The load balancer backend can communicate with OpenShift Container Platform nodes that run the Ingress Controller on ports 80, 443, and 1936.

Prerequisite for health check URL specifications

You can configure most load balancers by setting health check URLs that determine if a service is available or unavailable. OpenShift Container Platform provides these health checks for the OpenShift API, Machine Configuration API, and Ingress Controller backend services.

The following examples demonstrate health check specifications for the previously listed backend services:

Example of a Kubernetes API health check specification

```
Path: HTTPS:6443/readyz
Healthy threshold: 2
Unhealthy threshold: 2
Timeout: 10
Interval: 10
```

Example of a Machine Config API health check specification

```
Path: HTTPS:22623/healthz
Healthy threshold: 2
Unhealthy threshold: 2
Timeout: 10
Interval: 10
```

Example of an Ingress Controller health check specification

```
Path: HTTP:1936/healthz/ready
Healthy threshold: 2
Unhealthy threshold: 2
Timeout: 5
Interval: 10
```

Procedure

1. Configure the HAProxy Ingress Controller, so that you can enable access to the cluster from your load balancer on ports 6443, 443, and 80:

   #### Example HAProxy configuration

   ```
   #...
   listen my-cluster-api-6443
       bind 192.168.1.100:6443
       mode tcp
       balance roundrobin
     option httpchk
     http-check connect
     http-check send meth GET uri /readyz
     http-check expect status 200
       server my-cluster-master-2 192.168.1.101:6443 check inter 10s rise 2 fall 2
       server my-cluster-master-0 192.168.1.102:6443 check inter 10s rise 2 fall 2
       server my-cluster-master-1 192.168.1.103:6443 check inter 10s rise 2 fall 2

   listen my-cluster-machine-config-api-22623
       bind 192.168.1.1000.0.0.0:22623
       mode tcp
       balance roundrobin
     option httpchk
     http-check connect
     http-check send meth GET uri /healthz
     http-check expect status 200
       server my-cluster-master-2 192.0168.21.2101:22623 check inter 10s rise 2 fall 2
       server my-cluster-master-0 192.168.1.1020.2.3:22623 check inter 10s rise 2 fall 2
   ```

```
    server my-cluster-master-1 192.168.1.1030.2.1:22623 check inter 10s rise 2 fall 2

listen my-cluster-apps-443
        bind 192.168.1.100:443
        mode tcp
        balance roundrobin
    option httpchk
    http-check connect
    http-check send meth GET uri /healthz/ready
    http-check expect status 200
        server my-cluster-worker-0 192.168.1.111:443 check port 1936 inter 10s rise 2 fall 2
        server my-cluster-worker-1 192.168.1.112:443 check port 1936 inter 10s rise 2 fall 2
        server my-cluster-worker-2 192.168.1.113:443 check port 1936 inter 10s rise 2 fall 2

listen my-cluster-apps-80
        bind 192.168.1.100:80
        mode tcp
        balance roundrobin
    option httpchk
    http-check connect
    http-check send meth GET uri /healthz/ready
    http-check expect status 200
        server my-cluster-worker-0 192.168.1.111:80 check port 1936 inter 10s rise 2 fall 2
        server my-cluster-worker-1 192.168.1.112:80 check port 1936 inter 10s rise 2 fall 2
        server my-cluster-worker-2 192.168.1.113:80 check port 1936 inter 10s rise 2 fall 2
# ...
```

2. Use the **curl** CLI command to verify that the external load balancer and its resources are operational:

   a. Verify that the cluster machine configuration API is accessible to the Kubernetes API server resource, by running the following command and observing the response:

      ```
      $ curl https://<loadbalancer_ip_address>:6443/version --insecure
      ```

      If the configuration is correct, you receive a JSON object in response:

      ```
      {
        "major": "1",
        "minor": "11+",
        "gitVersion": "v1.11.0+ad103ed",
        "gitCommit": "ad103ed",
        "gitTreeState": "clean",
        "buildDate": "2019-01-09T06:44:10Z",
        "goVersion": "go1.10.3",
        "compiler": "gc",
        "platform": "linux/amd64"
      }
      ```

   b. Verify that the cluster machine configuration API is accessible to the Machine config server resource, by running the following command and observing the output:

      ```
      $ curl -v https://<loadbalancer_ip_address>:22623/healthz --insecure
      ```

      If the configuration is correct, the output from the command shows the following response:

```
HTTP/1.1 200 OK
Content-Length: 0
```

c. Verify that the controller is accessible to the Ingress Controller resource on port 80, by running the following command and observing the output:

```
$ curl -I -L -H "Host: console-openshift-console.apps.<cluster_name>.<base_domain>"
http://<load_balancer_front_end_IP_address>
```

If the configuration is correct, the output from the command shows the following response:

```
HTTP/1.1 302 Found
content-length: 0
location: https://console-openshift-console.apps.ocp4.private.opequon.net/
cache-control: no-cache
```

d. Verify that the controller is accessible to the Ingress Controller resource on port 443, by running the following command and observing the output:

```
$ curl -I -L --insecure --resolve console-openshift-console.apps.<cluster_name>.
<base_domain>:443:<Load Balancer Front End IP Address> https://console-openshift-
console.apps.<cluster_name>.<base_domain>
```

If the configuration is correct, the output from the command shows the following response:

```
HTTP/1.1 200 OK
referrer-policy: strict-origin-when-cross-origin
set-cookie: csrf-
token=UlYWOyQ62LWjw2h003xtYSKlh1a0Py2hhctw0WmV2YEdhJjFyQwWcGBsja261dG
LgaYO0nxzVErhiXt6QepA7g==; Path=/; Secure; SameSite=Lax
x-content-type-options: nosniff
x-dns-prefetch-control: off
x-frame-options: DENY
x-xss-protection: 1; mode=block
date: Wed, 04 Oct 2023 16:29:38 GMT
content-type: text/html; charset=utf-8
set-cookie:
1e2670d92730b515ce3a1bb65da45062=1bf5e9573c9a2760c964ed1659cc1673; path=/;
HttpOnly; Secure; SameSite=None
cache-control: private
```

3. Configure the DNS records for your cluster to target the front-end IP addresses of the external load balancer. You must update records to your DNS server for the cluster API and applications over the load balancer.

Examples of modified DNS records

```
<load_balancer_ip_address>  A  api.<cluster_name>.<base_domain>
A record pointing to Load Balancer Front End
```

```
<load_balancer_ip_address>  A apps.<cluster_name>.<base_domain>
A record pointing to Load Balancer Front End
```

IMPORTANT

DNS propagation might take some time for each DNS record to become available. Ensure that each DNS record propagates before validating each record.

4. Use the **curl** CLI command to verify that the external load balancer and DNS record configuration are operational:

   a. Verify that you can access the cluster API, by running the following command and observing the output:

   ```
   $ curl https://api.<cluster_name>.<base_domain>:6443/version --insecure
   ```

   If the configuration is correct, you receive a JSON object in response:

   ```
   {
     "major": "1",
     "minor": "11+",
     "gitVersion": "v1.11.0+ad103ed",
     "gitCommit": "ad103ed",
     "gitTreeState": "clean",
     "buildDate": "2019-01-09T06:44:10Z",
     "goVersion": "go1.10.3",
     "compiler": "gc",
     "platform": "linux/amd64"
     }
   ```

   b. Verify that you can access the cluster machine configuration, by running the following command and observing the output:

   ```
   $ curl -v https://api.<cluster_name>.<base_domain>:22623/healthz --insecure
   ```

   If the configuration is correct, the output from the command shows the following response:

   ```
   HTTP/1.1 200 OK
   Content-Length: 0
   ```

   c. Verify that you can access each cluster application on port, by running the following command and observing the output:

   ```
   $ curl http://console-openshift-console.apps.<cluster_name>.<base_domain> -I -L --
   insecure
   ```

   If the configuration is correct, the output from the command shows the following response:

   ```
   HTTP/1.1 302 Found
   content-length: 0
   location: https://console-openshift-console.apps.<cluster-name>.<base domain>/
   cache-control: no-cacheHTTP/1.1 200 OK
   referrer-policy: strict-origin-when-cross-origin
   set-cookie: csrf-
   token=39HoZgztDnzjJkq/JuLJMeoKNXlfiVv2YgZc09c3TBOBU4NI6kDXaJH1LdicNhN1UsQ
   Wzon4Dor9GWGfopaTEQ==; Path=/; Secure
   ```

```
x-content-type-options: nosniff
x-dns-prefetch-control: off
x-frame-options: DENY
x-xss-protection: 1; mode=block
date: Tue, 17 Nov 2020 08:42:10 GMT
content-type: text/html; charset=utf-8
set-cookie:
1e2670d92730b515ce3a1bb65da45062=9b714eb87e93cf34853e87a92d6894be; path=/;
HttpOnly; Secure; SameSite=None
cache-control: private
```

d. Verify that you can access each cluster application on port 443, by running the following command and observing the output:

```
$ curl https://console-openshift-console.apps.<cluster_name>.<base_domain> -I -L --
insecure
```

If the configuration is correct, the output from the command shows the following response:

```
HTTP/1.1 200 OK
referrer-policy: strict-origin-when-cross-origin
set-cookie: csrf-
token=UlYWOyQ62LWjw2h003xtYSKlh1a0Py2hhctw0WmV2YEdhJjFyQwWcGBsja261dG
LgaYO0nxzVErhiXt6QepA7g==; Path=/; Secure; SameSite=Lax
x-content-type-options: nosniff
x-dns-prefetch-control: off
x-frame-options: DENY
x-xss-protection: 1; mode=block
date: Wed, 04 Oct 2023 16:29:38 GMT
content-type: text/html; charset=utf-8
set-cookie:
1e2670d92730b515ce3a1bb65da45062=1bf5e9573c9a2760c964ed1659cc1673; path=/;
HttpOnly; Secure; SameSite=None
cache-control: private
```

21.7.19. Next steps

- Customize your cluster.
- If necessary, you can opt out of remote health reporting .
- If necessary, see Registering your disconnected cluster
- Set up your registry and configure registry storage .

21.8. INSTALLING A CLUSTER ON VSPHERE IN A RESTRICTED NETWORK WITH USER-PROVISIONED INFRASTRUCTURE

In OpenShift Container Platform version 4.11, you can install a cluster on VMware vSphere infrastructure that you provision in a restricted network.

NOTE

OpenShift Container Platform supports deploying a cluster to a single VMware vCenter only. Deploying a cluster with machines/machine sets on multiple vCenters is not supported.

IMPORTANT

The steps for performing a user-provisioned infrastructure installation are provided as an example only. Installing a cluster with infrastructure you provide requires knowledge of the vSphere platform and the installation process of OpenShift Container Platform. Use the user-provisioned infrastructure installation instructions as a guide; you are free to create the required resources through other methods.

21.8.1. Prerequisites

- You reviewed details about the OpenShift Container Platform installation and update processes.
- You read the documentation on selecting a cluster installation method and preparing it for users.
- You created a registry on your mirror host and obtained the **imageContentSources** data for your version of OpenShift Container Platform.

IMPORTANT

Because the installation media is on the mirror host, you can use that computer to complete all installation steps.

- You provisioned persistent storage for your cluster. To deploy a private image registry, your storage must provide **ReadWriteMany** access modes.
- Completing the installation requires that you upload the Red Hat Enterprise Linux CoreOS (RHCOS) OVA on vSphere hosts. The machine from which you complete this process requires access to port 443 on the vCenter and ESXi hosts. You verified that port 443 is accessible.
- If you use a firewall, you confirmed with the administrator that port 443 is accessible. Control plane nodes must be able to reach vCenter and ESXi hosts on port 443 for the installation to succeed.
- If you use a firewall and plan to use the Telemetry service, you configured the firewall to allow the sites that your cluster requires access to.

NOTE

Be sure to also review this site list if you are configuring a proxy.

21.8.2. About installations in restricted networks

In OpenShift Container Platform 4.11, you can perform an installation that does not require an active connection to the internet to obtain software components. Restricted network installations can be completed using installer-provisioned infrastructure or user-provisioned infrastructure, depending on the cloud platform to which you are installing the cluster.

If you choose to perform a restricted network installation on a cloud platform, you still require access to its cloud APIs. Some cloud functions, like Amazon Web Service's Route 53 DNS and IAM services, require internet access. Depending on your network, you might require less internet access for an installation on bare metal hardware or on VMware vSphere.

To complete a restricted network installation, you must create a registry that mirrors the contents of the OpenShift image registry and contains the installation media. You can create this registry on a mirror host, which can access both the internet and your closed network, or by using other methods that meet your restrictions.

IMPORTANT

Because of the complexity of the configuration for user-provisioned installations, consider completing a standard user-provisioned infrastructure installation before you attempt a restricted network installation using user-provisioned infrastructure. Completing this test installation might make it easier to isolate and troubleshoot any issues that might arise during your installation in a restricted network.

21.8.2.1. Additional limits

Clusters in restricted networks have the following additional limitations and restrictions:

- The **ClusterVersion** status includes an **Unable to retrieve available updates** error.
- By default, you cannot use the contents of the Developer Catalog because you cannot access the required image stream tags.

21.8.3. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.11, you require access to the internet to obtain the images that are necessary to install your cluster.

You must have internet access to:

- Access OpenShift Cluster Manager Hybrid Cloud Console to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access Quay.io to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.

IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

21.8.4. VMware vSphere infrastructure requirements

You must install the OpenShift Container Platform cluster on a VMware vSphere version 7 instance that meets the requirements for the components that you use.

NOTE

OpenShift Container Platform version 4.11 does not support VMware vSphere version 8.0.

You can host the VMware vSphere infrastructure on-premise or on a VMware Cloud Verified provider that meets the requirements outlined in the following table:

Table 21.76. Version requirements for vSphere virtual environments

Virtual environment product	Required version
VM hardware version	15 or later
vSphere ESXi hosts	7
vCenter host	7

IMPORTANT

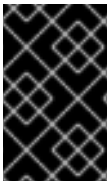
Installing a cluster on VMware vSphere version 7.0 Update 1 or earlier is now deprecated. These versions are still fully supported, but version 4.11 of OpenShift Container Platform requires vSphere virtual hardware version 15 or later. Hardware version 15 is now the default for vSphere virtual machines in OpenShift Container Platform. To update the hardware version for your vSphere nodes, see the "Updating hardware on nodes running in vSphere" article.

If your vSphere nodes are below hardware version 15 or your VMware vSphere version is earlier than 6.7.3, upgrading from OpenShift Container Platform 4.10 to OpenShift Container Platform 4.11 is not available.

Table 21.77. Minimum supported vSphere version for VMware components

Component	Minimum supported versions	Description
Hypervisor	vSphere 7 with HW version 15	This version is the minimum version that Red Hat Enterprise Linux CoreOS (RHCOS) supports. For more information about supported hardware on the latest version of Red Hat Enterprise Linux (RHEL) that is compatible with RHCOS, see Hardware on the Red Hat Customer Portal.
Storage with in-tree drivers	vSphere 7	This plugin creates vSphere storage by using the in-tree storage drivers for vSphere included in OpenShift Container Platform.

Component	Minimum supported versions	Description
Optional: Networking (NSX-T)	vSphere 7	vSphere 7 is required for OpenShift Container Platform. For more information about the compatibility of NSX and OpenShift Container Platform, see the Release Notes section of VMware's NSX container plugin documentation.



IMPORTANT

You must ensure that the time on your ESXi hosts is synchronized before you install OpenShift Container Platform. See Edit Time Configuration for a Host in the VMware documentation.

21.8.5. VMware vSphere CSI Driver Operator requirements

To install the vSphere CSI Driver Operator, the following requirements must be met:

- VMware vSphere version 7.0 Update 1 or later
- Virtual machines of hardware version 15 or later
- No third-party vSphere CSI driver already installed in the cluster

IMPORTANT

If a third-party vSphere CSI driver is present in the cluster, OpenShift Container Platform does not overwrite it. If you continue with the third-party vSphere CSI driver when upgrading to the next major version of OpenShift Container Platform, the **oc** CLI prompts you with the following message:

```
VSphereCSIDriverOperatorCRUpgradeable: VMwareVSphereControllerUpgradeable:
found existing unsupported csi.vsphere.vmware.com driver
```

The previous message informs you that Red Hat does not support the third-party vSphere CSI driver during an OpenShift Container Platform upgrade operation. You can choose to ignore this message and continue with the upgrade operation.

Additional resources

- To remove a third-party vSphere CSI driver, see Removing a third-party vSphere CSI Driver .
- To update the hardware version for your vSphere nodes, see Updating hardware on nodes running in vSphere.

21.8.6. Requirements for a cluster with user-provisioned infrastructure

For a cluster that contains user-provisioned infrastructure, you must deploy all of the required machines.

This section describes the requirements for deploying OpenShift Container Platform on user-provisioned infrastructure.

21.8.6.1. Required machines for cluster installation

The smallest OpenShift Container Platform clusters require the following hosts:

Table 21.78. Minimum required hosts

Hosts	Description
One temporary bootstrap machine	The cluster requires the bootstrap machine to deploy the OpenShift Container Platform cluster on the three control plane machines. You can remove the bootstrap machine after you install the cluster.
Three control plane machines	The control plane machines run the Kubernetes and OpenShift Container Platform services that form the control plane.
At least two compute machines, which are also known as worker machines.	The workloads requested by OpenShift Container Platform users run on the compute machines.

IMPORTANT

To maintain high availability of your cluster, use separate physical hosts for these cluster machines.

The bootstrap and control plane machines must use Red Hat Enterprise Linux CoreOS (RHCOS) as the operating system. However, the compute machines can choose between Red Hat Enterprise Linux CoreOS (RHCOS), Red Hat Enterprise Linux (RHEL) 8.6 and later.

Note that RHCOS is based on Red Hat Enterprise Linux (RHEL) 8 and inherits all of its hardware certifications and requirements. See Red Hat Enterprise Linux technology capabilities and limits .

21.8.6.2. Minimum resource requirements for cluster installation

Each cluster machine must meet the following minimum requirements:

Table 21.79. Minimum resource requirements

Machine	Operating System	vCPU	Virtual RAM	Storage	Input/Output Per Second (IOPS)[1]
Bootstrap	RHCOS	4	16 GB	100 GB	300
Control plane	RHCOS	4	16 GB	100 GB	300

Machine	Operating System	vCPU	Virtual RAM	Storage	Input/Output Per Second (IOPS)[1]
Compute	RHCOS, RHEL 8.6 and later [2]	2	8 GB	100 GB	300

1. OpenShift Container Platform and Kubernetes are sensitive to disk performance, and faster storage is recommended, particularly for etcd on the control plane nodes which require a 10 ms p99 fsync duration. Note that on many cloud platforms, storage size and IOPS scale together, so you might need to over-allocate storage volume to obtain sufficient performance.

2. As with all user-provisioned installations, if you choose to use RHEL compute machines in your cluster, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks. Use of RHEL 7 compute machines is deprecated and has been removed in OpenShift Container Platform 4.10 and later.

If an instance type for your platform meets the minimum requirements for cluster machines, it is supported to use in OpenShift Container Platform.

Additional resources

- Optimizing storage

21.8.6.3. Certificate signing requests management

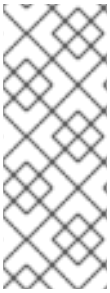
Because your cluster has limited access to automatic machine management when you use infrastructure that you provision, you must provide a mechanism for approving cluster certificate signing requests (CSRs) after installation. The **kube-controller-manager** only approves the kubelet client CSRs. The **machine-approver** cannot guarantee the validity of a serving certificate that is requested by using kubelet credentials because it cannot confirm that the correct machine issued the request. You must determine and implement a method of verifying the validity of the kubelet serving certificate requests and approving them.

21.8.6.4. Networking requirements for user-provisioned infrastructure

All the Red Hat Enterprise Linux CoreOS (RHCOS) machines require networking to be configured in **initramfs** during boot to fetch their Ignition config files.

During the initial boot, the machines require an IP address configuration that is set either through a DHCP server or statically by providing the required boot options. After a network connection is established, the machines download their Ignition config files from an HTTP or HTTPS server. The Ignition config files are then used to set the exact state of each machine. The Machine Config Operator completes more changes to the machines, such as the application of new certificates or keys, after installation.

It is recommended to use a DHCP server for long-term management of the cluster machines. Ensure that the DHCP server is configured to provide persistent IP addresses, DNS server information, and hostnames to the cluster machines.



NOTE

If a DHCP service is not available for your user-provisioned infrastructure, you can instead provide the IP networking configuration and the address of the DNS server to the nodes at RHCOS install time. These can be passed as boot arguments if you are installing from an ISO image. See the *Installing RHCOS and starting the OpenShift Container Platform bootstrap process* section for more information about static IP provisioning and advanced networking options.

The Kubernetes API server must be able to resolve the node names of the cluster machines. If the API servers and worker nodes are in different zones, you can configure a default DNS search zone to allow the API server to resolve the node names. Another supported approach is to always refer to hosts by their fully-qualified domain names in both the node objects and all DNS requests.

21.8.6.4.1. Setting the cluster node hostnames through DHCP

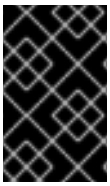
On Red Hat Enterprise Linux CoreOS (RHCOS) machines, the hostname is set through NetworkManager. By default, the machines obtain their hostname through DHCP. If the hostname is not provided by DHCP, set statically through kernel arguments, or another method, it is obtained through a reverse DNS lookup. Reverse DNS lookup occurs after the network has been initialized on a node and can take time to resolve. Other system services can start prior to this and detect the hostname as **localhost** or similar. You can avoid this by using DHCP to provide the hostname for each cluster node.

Additionally, setting the hostnames through DHCP can bypass any manual DNS record name configuration errors in environments that have a DNS split-horizon implementation.

21.8.6.4.2. Network connectivity requirements

You must configure the network connectivity between machines to allow OpenShift Container Platform cluster components to communicate. Each machine must be able to resolve the hostnames of all other machines in the cluster.

This section provides details about the ports that are required.



IMPORTANT

In connected OpenShift Container Platform environments, all nodes are required to have internet access to pull images for platform containers and provide telemetry data to Red Hat.

Table 21.80. Ports used for all-machine to all-machine communications

Protocol	Port	Description
ICMP	N/A	Network reachability tests
TCP	**1936**	Metrics
	9000-**9999**	Host level services, including the node exporter on ports **9100**-**9101** and the Cluster Version Operator on port**9099**.
	10250-**10259**	The default ports that Kubernetes reserves

Protocol	Port	Description
	10256	openshift-sdn
UDP	**4789**	VXLAN
	6081	Geneve
	9000-**9999**	Host level services, including the node exporter on ports **9100**-**9101**.
	500	IPsec IKE packets
	4500	IPsec NAT-T packets
TCP/UDP	**30000**-**32767**	Kubernetes node port
ESP	N/A	IPsec Encapsulating Security Payload (ESP)

Table 21.81. Ports used for all-machine to control plane communications

Protocol	Port	Description
TCP	**6443**	Kubernetes API

Table 21.82. Ports used for control plane machine to control plane machine communications

Protocol	Port	Description
TCP	**2379**-**2380**	etcd server and peer ports

Ethernet adaptor hardware address requirements
When provisioning VMs for the cluster, the ethernet interfaces configured for each VM must use a MAC address from the VMware Organizationally Unique Identifier (OUI) allocation ranges:

- **00:05:69:00:00:00** to **00:05:69:FF:FF:FF**
- **00:0c:29:00:00:00** to **00:0c:29:FF:FF:FF**
- **00:1c:14:00:00:00** to **00:1c:14:FF:FF:FF**
- **00:50:56:00:00:00** to **00:50:56:3F:FF:FF**

If a MAC address outside the VMware OUI is used, the cluster installation will not succeed.

NTP configuration for user-provisioned infrastructure
OpenShift Container Platform clusters are configured to use a public Network Time Protocol (NTP) server by default. If you want to use a local enterprise NTP server, or if your cluster is being deployed in a

disconnected network, you can configure the cluster to use a specific time server. For more information, see the documentation for *Configuring chrony time service* .

If a DHCP server provides NTP server information, the chrony time service on the Red Hat Enterprise Linux CoreOS (RHCOS) machines read the information and can sync the clock with the NTP servers.

Additional resources

- Configuring chrony time service

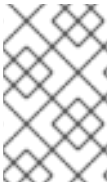
21.8.6.5. User-provisioned DNS requirements

In OpenShift Container Platform deployments, DNS name resolution is required for the following components:

- The Kubernetes API
- The OpenShift Container Platform application wildcard
- The bootstrap, control plane, and compute machines

Reverse DNS resolution is also required for the Kubernetes API, the bootstrap machine, the control plane machines, and the compute machines.

DNS A/AAAA or CNAME records are used for name resolution and PTR records are used for reverse name resolution. The reverse records are important because Red Hat Enterprise Linux CoreOS (RHCOS) uses the reverse records to set the hostnames for all the nodes, unless the hostnames are provided by DHCP. Additionally, the reverse records are used to generate the certificate signing requests (CSR) that OpenShift Container Platform needs to operate.



NOTE

It is recommended to use a DHCP server to provide the hostnames to each cluster node. See the *DHCP recommendations for user-provisioned infrastructure* section for more information.

The following DNS records are required for a user-provisioned OpenShift Container Platform cluster and they must be in place before installation. In each record, **<cluster_name>** is the cluster name and **<base_domain>** is the base domain that you specify in the **install-config.yaml** file. A complete DNS record takes the form: **<component>.<cluster_name>.<base_domain>.**.

Table 21.83. Required DNS records

Component	Record	Description
Kubernetes API	**api.<cluster_name>.<base_domain>.**	A DNS A/AAAA or CNAME record, and a DNS PTR record, to identify the API load balancer. These records must be resolvable by both clients external to the cluster and from all the nodes within the cluster.

Component	Record	Description
	api-int.<cluster_name>.<base_domain>.	A DNS A/AAAA or CNAME record, and a DNS PTR record, to internally identify the API load balancer. These records must be resolvable from all the nodes within the cluster.  **IMPORTANT** The API server must be able to resolve the worker nodes by the hostnames that are recorded in Kubernetes. If the API server cannot resolve the node names, then proxied API calls can fail, and you cannot retrieve logs from pods.
Routes	***.apps.<cluster_name>.<base_domain>.**	A wildcard DNS A/AAAA or CNAME record that refers to the application ingress load balancer. The application ingress load balancer targets the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default. These records must be resolvable by both clients external to the cluster and from all the nodes within the cluster. For example, **console-openshift-console.apps.<cluster_name>.<base_domain>** is used as a wildcard route to the OpenShift Container Platform console.
Bootstrap machine	**bootstrap.<cluster_name>.<base_domain>.**	A DNS A/AAAA or CNAME record, and a DNS PTR record, to identify the bootstrap machine. These records must be resolvable by the nodes within the cluster.
Control plane machines	**<master><n>.<cluster_name>.<base_domain>.**	DNS A/AAAA or CNAME records and DNS PTR records to identify each machine for the control plane nodes. These records must be resolvable by the nodes within the cluster.
Compute machines	**<worker><n>.<cluster_name>.<base_domain>.**	DNS A/AAAA or CNAME records and DNS PTR records to identify each machine for the worker nodes. These records must be resolvable by the nodes within the cluster.

NOTE

In OpenShift Container Platform 4.4 and later, you do not need to specify etcd host and SRV records in your DNS configuration.

TIP

You can use the **dig** command to verify name and reverse name resolution. See the section on *Validating DNS resolution for user-provisioned infrastructure* for detailed validation steps.

21.8.6.5.1. Example DNS configuration for user-provisioned clusters

This section provides A and PTR record configuration samples that meet the DNS requirements for deploying OpenShift Container Platform on user-provisioned infrastructure. The samples are not meant to provide advice for choosing one DNS solution over another.

In the examples, the cluster name is **ocp4** and the base domain is **example.com**.

Example DNS A record configuration for a user-provisioned cluster

The following example is a BIND zone file that shows sample A records for name resolution in a user-provisioned cluster.

Example 21.19. Sample DNS zone database

```
$TTL 1W
@ IN SOA ns1.example.com. root (
  2019070700 ; serial
  3H  ; refresh (3 hours)
  30M  ; retry (30 minutes)
  2W  ; expiry (2 weeks)
  1W )  ; minimum (1 week)
 IN NS ns1.example.com.
 IN MX 10 smtp.example.com.
;
;
ns1.example.com.  IN A 192.168.1.5
smtp.example.com.  IN A 192.168.1.5
;
helper.example.com.  IN A 192.168.1.5
helper.ocp4.example.com. IN A 192.168.1.5
;
api.ocp4.example.com.  IN A 192.168.1.5 1
api-int.ocp4.example.com. IN A 192.168.1.5 2
;
*.apps.ocp4.example.com. IN A 192.168.1.5 3
;
bootstrap.ocp4.example.com. IN A 192.168.1.96 4
;
master0.ocp4.example.com. IN A 192.168.1.97 5
master1.ocp4.example.com. IN A 192.168.1.98 6
master2.ocp4.example.com. IN A 192.168.1.99 7
;
worker0.ocp4.example.com. IN A 192.168.1.11 8
worker1.ocp4.example.com. IN A 192.168.1.7 9
;
;EOF
```

1. Provides name resolution for the Kubernetes API. The record refers to the IP address of the API load balancer.
2. Provides name resolution for the Kubernetes API. The record refers to the IP address of the API load balancer and is used for internal cluster communications.
3. Provides name resolution for the wildcard routes. The record refers to the IP address of the

NOTE

In the example, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

4 Provides name resolution for the bootstrap machine.

5 6 7 Provides name resolution for the control plane machines.

8 9 Provides name resolution for the compute machines.

Example DNS PTR record configuration for a user-provisioned cluster

The following example BIND zone file shows sample PTR records for reverse name resolution in a user-provisioned cluster.

Example 21.20. Sample DNS zone database for reverse records

```
$TTL 1W
@ IN SOA ns1.example.com. root (
  2019070700 ; serial
  3H  ; refresh (3 hours)
  30M  ; retry (30 minutes)
  2W  ; expiry (2 weeks)
  1W )  ; minimum (1 week)
 IN NS ns1.example.com.
;
5.1.168.192.in-addr.arpa. IN PTR api.ocp4.example.com. 1
5.1.168.192.in-addr.arpa. IN PTR api-int.ocp4.example.com. 2
;
96.1.168.192.in-addr.arpa. IN PTR bootstrap.ocp4.example.com. 3
;
97.1.168.192.in-addr.arpa. IN PTR master0.ocp4.example.com. 4
98.1.168.192.in-addr.arpa. IN PTR master1.ocp4.example.com. 5
99.1.168.192.in-addr.arpa. IN PTR master2.ocp4.example.com. 6
;
11.1.168.192.in-addr.arpa. IN PTR worker0.ocp4.example.com. 7
7.1.168.192.in-addr.arpa. IN PTR worker1.ocp4.example.com. 8
;
;EOF
```

1 Provides reverse DNS resolution for the Kubernetes API. The PTR record refers to the record name of the API load balancer.

2 Provides reverse DNS resolution for the Kubernetes API. The PTR record refers to the record name of the API load balancer and is used for internal cluster communications.

3 Provides reverse DNS resolution for the bootstrap machine.

4 5 6 Provides reverse DNS resolution for the control plane machines.

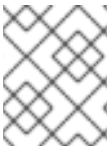
7 8 Provides reverse DNS resolution for the compute machines.

NOTE

A PTR record is not required for the OpenShift Container Platform application wildcard.

21.8.6.6. Load balancing requirements for user-provisioned infrastructure

Before you install OpenShift Container Platform, you must provision the API and application ingress load balancing infrastructure. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.



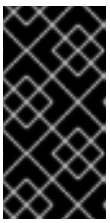
NOTE

If you want to deploy the API and application Ingress load balancers with a Red Hat Enterprise Linux (RHEL) instance, you must purchase the RHEL subscription separately.

The load balancing infrastructure must meet the following requirements:

1. **API load balancer**: Provides a common endpoint for users, both human and machine, to interact with and configure the platform. Configure the following conditions:

   - Layer 4 load balancing only. This can be referred to as Raw TCP, SSL Passthrough, or SSL Bridge mode. If you use SSL Bridge mode, you must enable Server Name Indication (SNI) for the API routes.
   - A stateless load balancing algorithm. The options vary based on the load balancer implementation.



IMPORTANT

Do not configure session persistence for an API load balancer. Configuring session persistence for a Kubernetes API server might cause performance issues from excess application traffic for your OpenShift Container Platform cluster and the Kubernetes API that runs inside the cluster.

Configure the following ports on both the front and back of the load balancers:

Table 21.84. API load balancer

Port	Back-end machines (pool members)	Internal	External	Description
6443	Bootstrap and control plane. You remove the bootstrap machine from the load balancer after the bootstrap machine initializes the cluster control plane. You must configure the **/readyz** endpoint for the API server health check probe.	X	X	Kubernetes API server

Port	Back-end machines (pool members)	Internal	External	Description
22623	Bootstrap and control plane. You remove the bootstrap machine from the load balancer after the bootstrap machine initializes the cluster control plane.	X		Machine config server

NOTE

The load balancer must be configured to take a maximum of 30 seconds from the time the API server turns off the **/readyz** endpoint to the removal of the API server instance from the pool. Within the time frame after **/readyz** returns an error or becomes healthy, the endpoint must have been removed or added. Probing every 5 or 10 seconds, with two successful requests to become healthy and three to become unhealthy, are well-tested values.

2. **Application Ingress load balancer**: Provides an ingress point for application traffic flowing in from outside the cluster. A working configuration for the Ingress router is required for an OpenShift Container Platform cluster.
Configure the following conditions:

   - Layer 4 load balancing only. This can be referred to as Raw TCP, SSL Passthrough, or SSL Bridge mode. If you use SSL Bridge mode, you must enable Server Name Indication (SNI) for the ingress routes.
   - A connection-based or session-based persistence is recommended, based on the options available and types of applications that will be hosted on the platform.

TIP

If the true IP address of the client can be seen by the application Ingress load balancer, enabling source IP-based session persistence can improve performance for applications that use end-to-end TLS encryption.

Configure the following ports on both the front and back of the load balancers:

Table 21.85. Application Ingress load balancer

Port	Back-end machines (pool members)	Internal	External	Description
443	The machines that run the Ingress Controller pods, compute, or worker, by default.	X	X	HTTPS traffic
80	The machines that run the Ingress Controller pods, compute, or worker, by default.	X	X	HTTP traffic

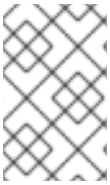
NOTE

If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application Ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes.

21.8.6.6.1. Example load balancer configuration for user-provisioned clusters

This section provides an example API and application ingress load balancer configuration that meets the load balancing requirements for user-provisioned clusters. The sample is an **/etc/haproxy/haproxy.cfg** configuration for an HAProxy load balancer. The example is not meant to provide advice for choosing one load balancing solution over another.

In the example, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.



NOTE

If you are using HAProxy as a load balancer and SELinux is set to **enforcing**, you must ensure that the HAProxy service can bind to the configured TCP port by running **setsebool -P haproxy_connect_any=1**.

Example 21.21. Sample API and application Ingress load balancer configuration

```
global
  log         127.0.0.1 local2
  pidfile     /var/run/haproxy.pid
  maxconn     4000
  daemon
defaults
  mode                    http
  log                     global
  option                  dontlognull
  option http-server-close
  option                  redispatch
  retries                 3
  timeout http-request    10s
  timeout queue           1m
  timeout connect         10s
  timeout client          1m
  timeout server          1m
  timeout http-keep-alive 10s
  timeout check           10s
  maxconn                 3000
listen api-server-6443 (1)
  bind *:6443
  mode tcp
  server bootstrap bootstrap.ocp4.example.com:6443 check inter 1s backup (2)
  server master0 master0.ocp4.example.com:6443 check inter 1s
  server master1 master1.ocp4.example.com:6443 check inter 1s
  server master2 master2.ocp4.example.com:6443 check inter 1s
listen machine-config-server-22623 (3)
```

```
  bind *:22623
  mode tcp
  option  httpchk GET /readyz HTTP/1.0
  option  log-health-checks
  balance roundrobin
  server bootstrap bootstrap.ocp4.example.com:6443 verify none check check-ssl inter 10s fall 2
rise 3 backup 4
  server master0 master0.ocp4.example.com:6443 weight 1 verify none check check-ssl inter 10s
fall 2 rise 3
  server master1 master1.ocp4.example.com:6443 weight 1 verify none check check-ssl inter 10s
fall 2 rise 3
  server master2 master2.ocp4.example.com:6443 weight 1 verify none check check-ssl inter 10s
fall 2 rise 3
listen ingress-router-443 5
  bind *:443
  mode tcp
  balance source
  server worker0 worker0.ocp4.example.com:443 check inter 1s
  server worker1 worker1.ocp4.example.com:443 check inter 1s
listen ingress-router-80 6
  bind *:80
  mode tcp
  balance source
  server worker0 worker0.ocp4.example.com:80 check inter 1s
  server worker1 worker1.ocp4.example.com:80 check inter 1s
```

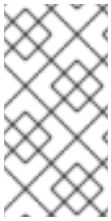
1 Port **6443** handles the Kubernetes API traffic and points to the control plane machines.

2 4 The bootstrap entries must be in place before the OpenShift Container Platform cluster installation and they must be removed after the bootstrap process is complete.

3 Port **22623** handles the machine config server traffic and points to the control plane machines.

5 Port **443** handles the HTTPS traffic and points to the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.

6 Port **80** handles the HTTP traffic and points to the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.



NOTE

If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application Ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes.

TIP

If you are using HAProxy as a load balancer, you can check that the **haproxy** process is listening on ports **6443**, **22623**, **443**, and **80** by running **netstat -nltupe** on the HAProxy node.

21.8.7. Preparing the user-provisioned infrastructure

Before you install OpenShift Container Platform on user-provisioned infrastructure, you must prepare the underlying infrastructure.

This section provides details about the high-level steps required to set up your cluster infrastructure in preparation for an OpenShift Container Platform installation. This includes configuring IP networking and network connectivity for your cluster nodes, enabling the required ports through your firewall, and setting up the required DNS and load balancing infrastructure.

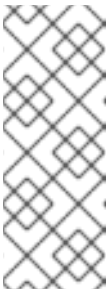
After preparation, your cluster infrastructure must meet the requirements outlined in the *Requirements for a cluster with user-provisioned infrastructure* section.

Prerequisites

- You have reviewed the OpenShift Container Platform 4.x Tested Integrations page.
- You have reviewed the infrastructure requirements detailed in the *Requirements for a cluster with user-provisioned infrastructure* section.

Procedure

1. If you are using DHCP to provide the IP networking configuration to your cluster nodes, configure your DHCP service.
   a. Add persistent IP addresses for the nodes to your DHCP server configuration. In your configuration, match the MAC address of the relevant network interface to the intended IP address for each node.
   b. When you use DHCP to configure IP addressing for the cluster machines, the machines also obtain the DNS server information through DHCP. Define the persistent DNS server address that is used by the cluster nodes through your DHCP server configuration.



NOTE

If you are not using a DHCP service, you must provide the IP networking configuration and the address of the DNS server to the nodes at RHCOS install time. These can be passed as boot arguments if you are installing from an ISO image. See the *Installing RHCOS and starting the OpenShift Container Platform bootstrap process* section for more information about static IP provisioning and advanced networking options.

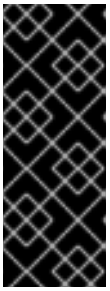
   c. Define the hostnames of your cluster nodes in your DHCP server configuration. See the *Setting the cluster node hostnames through DHCP* section for details about hostname considerations.

NOTE

If you are not using a DHCP service, the cluster nodes obtain their hostname through a reverse DNS lookup.

2. Ensure that your network infrastructure provides the required network connectivity between the cluster components. See the *Networking requirements for user-provisioned infrastructure* section for details about the requirements.

3. Configure your firewall to enable the ports required for the OpenShift Container Platform cluster components to communicate. See *Networking requirements for user-provisioned infrastructure* section for details about the ports that are required.



IMPORTANT

By default, port **1936** is accessible for an OpenShift Container Platform cluster, because each control plane node needs access to this port.

Avoid using the Ingress load balancer to expose this port, because doing so might result in the exposure of sensitive information, such as statistics and metrics, related to Ingress Controllers.

4. Setup the required DNS infrastructure for your cluster.
   a. Configure DNS name resolution for the Kubernetes API, the application wildcard, the bootstrap machine, the control plane machines, and the compute machines.
   b. Configure reverse DNS resolution for the Kubernetes API, the bootstrap machine, the control plane machines, and the compute machines.
   See the *User-provisioned DNS requirements* section for more information about the OpenShift Container Platform DNS requirements.
5. Validate your DNS configuration.
   a. From your installation node, run DNS lookups against the record names of the Kubernetes API, the wildcard routes, and the cluster nodes. Validate that the IP addresses in the responses correspond to the correct components.
   b. From your installation node, run reverse DNS lookups against the IP addresses of the load balancer and the cluster nodes. Validate that the record names in the responses correspond to the correct components.
   See the *Validating DNS resolution for user-provisioned infrastructure* section for detailed DNS validation steps.
6. Provision the required API and application ingress load balancing infrastructure. See the *Load balancing requirements for user-provisioned infrastructure* section for more information about the requirements.

NOTE

Some load balancing solutions require the DNS name resolution for the cluster nodes to be in place before the load balancing is initialized.

21.8.8. Validating DNS resolution for user-provisioned infrastructure

You can validate your DNS configuration before installing OpenShift Container Platform on user-provisioned infrastructure.

IMPORTANT

The validation steps detailed in this section must succeed before you install your cluster.

Prerequisites

- You have configured the required DNS records for your user-provisioned infrastructure.

Procedure

1. From your installation node, run DNS lookups against the record names of the Kubernetes API, the wildcard routes, and the cluster nodes. Validate that the IP addresses contained in the responses correspond to the correct components.

   a. Perform a lookup against the Kubernetes API record name. Check that the result points to the IP address of the API load balancer:

   ```
   $ dig +noall +answer @<nameserver_ip> api.<cluster_name>.<base_domain>
   ```
   (1)

   (1) Replace **<nameserver_ip>** with the IP address of the nameserver, **<cluster_name>** with your cluster name, and **<base_domain>** with your base domain name.

   Example output

   ```
   api.ocp4.example.com.  604800 IN A 192.168.1.5
   ```

   b. Perform a lookup against the Kubernetes internal API record name. Check that the result points to the IP address of the API load balancer:

   ```
   $ dig +noall +answer @<nameserver_ip> api-int.<cluster_name>.<base_domain>
   ```

   Example output

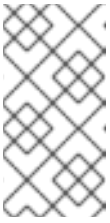
   ```
   api-int.ocp4.example.com.  604800 IN A 192.168.1.5
   ```

   c. Test an example ***.apps.<cluster_name>.<base_domain>** DNS wildcard lookup. All of the application wildcard lookups must resolve to the IP address of the application ingress load balancer:

   ```
   $ dig +noall +answer @<nameserver_ip> random.apps.<cluster_name>.<base_domain>
   ```

   Example output

   ```
   random.apps.ocp4.example.com.  604800 IN A 192.168.1.5
   ```

   NOTE

   In the example outputs, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

   You can replace **random** with another wildcard value. For example, you can query the route to the OpenShift Container Platform console:

   ```
   $ dig +noall +answer @<nameserver_ip> console-openshift-console.apps.
   <cluster_name>.<base_domain>
   ```

Example output

```
console-openshift-console.apps.ocp4.example.com. 604800 IN A 192.168.1.5
```

d. Run a lookup against the bootstrap DNS record name. Check that the result points to the IP address of the bootstrap node:

```
$ dig +noall +answer @<nameserver_ip> bootstrap.<cluster_name>.<base_domain>
```

Example output

```
bootstrap.ocp4.example.com.  604800 IN A 192.168.1.96
```

e. Use this method to perform lookups against the DNS record names for the control plane and compute nodes. Check that the results correspond to the IP addresses of each node.

2. From your installation node, run reverse DNS lookups against the IP addresses of the load balancer and the cluster nodes. Validate that the record names contained in the responses correspond to the correct components.

a. Perform a reverse lookup against the IP address of the API load balancer. Check that the response includes the record names for the Kubernetes API and the Kubernetes internal API:

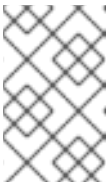
```
$ dig +noall +answer @<nameserver_ip> -x 192.168.1.5
```

Example output

```
5.1.168.192.in-addr.arpa. 604800 IN PTR api-int.ocp4.example.com. 1
5.1.168.192.in-addr.arpa. 604800 IN PTR api.ocp4.example.com. 2
```

1 Provides the record name for the Kubernetes internal API.

2 Provides the record name for the Kubernetes API.



NOTE

A PTR record is not required for the OpenShift Container Platform application wildcard. No validation step is needed for reverse DNS resolution against the IP address of the application ingress load balancer.

b. Perform a reverse lookup against the IP address of the bootstrap node. Check that the result points to the DNS record name of the bootstrap node:

```
$ dig +noall +answer @<nameserver_ip> -x 192.168.1.96
```

Example output

```
96.1.168.192.in-addr.arpa. 604800 IN PTR bootstrap.ocp4.example.com.
```

c. Use this method to perform reverse lookups against the IP addresses for the control plane and compute nodes. Check that the results correspond to the DNS record names of each node.

21.8.9. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the **~/.ssh/authorized_keys** list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The **./openshift-install gather** command also requires the SSH public key to be in place on the cluster nodes.

IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.

NOTE

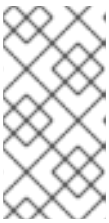
You must use a local key, not one that you configured with platform-specific approaches such as AWS key pairs.

Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N '' -f <path>/<file_name> 1
```

1 Specify the path and file name, such as **~/.ssh/id_ed25519**, of the new SSH key. If you have an existing key pair, ensure your public key is in the your **~/.ssh** directory.



NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS validated or Modules In Process cryptographic libraries on the **x86_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

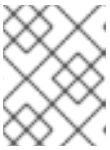
2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the **~/.ssh/id_ed25519.pub** public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the **./openshift-install gather** command.



NOTE

On some distributions, default SSH private key identities such as **~/.ssh/id_rsa** and **~/.ssh/id_dsa** are managed automatically.

   a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

Example output

```
Agent pid 31874
```

NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

1 Specify the path and file name for your SSH private key, such as **~/.ssh/id_ed25519**

Example output

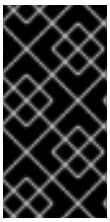
```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program. If you install a cluster on infrastructure that you provision, you must provide the key to the installation program.

21.8.10. Manually creating the installation configuration file

For user-provisioned installations of OpenShift Container Platform, you manually generate your installation configuration file.



IMPORTANT

The Cluster Cloud Controller Manager Operator performs a connectivity check on a provided hostname or IP address. Ensure that you specify a hostname or an IP address to a reachable vCenter server. If you provide metadata to a non-existent vCenter server, installation of the cluster fails at the bootstrap stage.

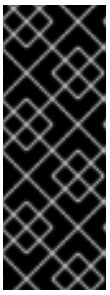
Prerequisites

- You have an SSH public key on your local machine to provide to the installation program. The key will be used for SSH authentication onto your cluster nodes for debugging and disaster recovery.
- You have obtained the OpenShift Container Platform installation program and the pull secret for your cluster.
- Obtain the **imageContentSources** section from the output of the command to mirror the repository.
- Obtain the contents of the certificate for your mirror registry.

Procedure

1. Create an installation directory to store your required installation assets in:

```
$ mkdir <installation_directory>
```



IMPORTANT

You must create a directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

2. Customize the sample **install-config.yaml** file template that is provided and save it in the **<installation_directory>**.

NOTE

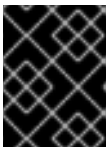
You must name this configuration file **install-config.yaml**.

- Unless you use a registry that RHCOS trusts by default, such as **docker.io**, you must provide the contents of the certificate for your mirror repository in the **additionalTrustBundle** section. In most cases, you must provide the certificate for your mirror.
- You must include the **imageContentSources** section from the output of the command to mirror the repository.

NOTE

For some platform types, you can alternatively run **./openshift-install create install-config --dir <installation_directory>** to generate an **install-config.yaml** file. You can provide details about your cluster configuration at the prompts.

3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.



IMPORTANT

The **install-config.yaml** file is consumed during the next step of the installation process. You must back it up now.

21.8.10.1. Sample install-config.yaml file for VMware vSphere

You can customize the **install-config.yaml** file to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.

```
apiVersion: v1
baseDomain: example.com (1)
compute: (2)
  name: worker
  replicas: 0 (3)
controlPlane: (4)
  name: master
  replicas: 3 (5)
metadata:
  name: test (6)
platform:
  vsphere:
    vcenter: your.vcenter.server (7)
    username: username (8)
    password: password (9)
    datacenter: datacenter (10)
    defaultDatastore: datastore (11)
    folder: "/<datacenter_name>/vm/<folder_name>/<subfolder_name>" (12)
    resourcePool: "/<datacenter_name>/host/<cluster_name>/Resources/<resource_pool_name>" (13)
    diskType: thin (14)
fips: false (15)
pullSecret: '{"auths":{"<local_registry>": {"auth": "<credentials>","email": "you@example.com"}}}' (16)
sshKey: 'ssh-ed25519 AAAA...' (17)
additionalTrustBundle: | (18)
  -----BEGIN CERTIFICATE-----
  ZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZ
  -----END CERTIFICATE-----
imageContentSources: (19)
- mirrors:
  - <mirror_host_name>:<mirror_port>/<repo_name>/release
  source: <source_image_1>
```

```
- mirrors:
  - <mirror_host_name>:<mirror_port>/<repo_name>/release-images
  source: <source_image_2>
```

1. The base domain of the cluster. All DNS records must be sub-domains of this base and include the cluster name.

2 4. The **controlPlane** section is a single mapping, but the compute section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, (**-**), and the first line of the **controlPlane** section must not. Although both sections currently define a single machine pool, it is possible that future versions of OpenShift Container Platform will support defining multiple compute pools during installation. Only one control plane pool is used.

3. You must set the value of the **replicas** parameter to **0**. This parameter controls the number of workers that the cluster creates and manages for you, which are functions that the cluster does not perform when you use user-provisioned infrastructure. You must manually deploy worker machines for the cluster to use before you finish installing OpenShift Container Platform.

5. The number of control plane machines that you add to the cluster. Because the cluster uses this values as the number of etcd endpoints in the cluster, the value must match the number of control plane machines that you deploy.

6. The cluster name that you specified in your DNS records.

7. The fully-qualified hostname or IP address of the vCenter server.

IMPORTANT

The Cluster Cloud Controller Manager Operator performs a connectivity check on a provided hostname or IP address. Ensure that you specify a hostname or an IP address to a reachable vCenter server. If you provide metadata to a non-existent vCenter server, installation of the cluster fails at the bootstrap stage.

8. The name of the user for accessing the server.

9. The password associated with the vSphere user.

10. The vSphere datacenter.

11. The default vSphere datastore to use.

12. Optional parameter: For installer-provisioned infrastructure, the absolute path of an existing folder where the installation program creates the virtual machines, for example, **/<datacenter_name>/vm/<folder_name>/<subfolder_name>**. If you do not provide this value, the installation program creates a top-level folder in the datacenter virtual machine folder that is named with the infrastructure ID. If you are providing the infrastructure for the cluster and you do not want to use the default **StorageClass** object, named **thin**, you can omit the **folder** parameter from the **install-config.yaml** file.

13. Optional parameter: For installer-provisioned infrastructure, the absolute path of an existing folder where the installation program creates the virtual machines, for example, **/<datacenter_name>/vm/<folder_name>/<subfolder_name>**. If you do not provide this value, the installation program creates a top-level folder in the datacenter virtual machine folder that is named with the infrastructure ID. If you are providing the infrastructure for the cluster, omit this parameter.

14 The vSphere disk provisioning method.

15 Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.

IMPORTANT

To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.

16 For **<local_registry>**, specify the registry domain name, and optionally the port, that your mirror registry uses to serve content. For example **registry.example.com** or **registry.example.com:5000**. For **<credentials>**, specify the base64-encoded user name and password for your mirror registry.

17 The public portion of the default SSH key for the **core** user in Red Hat Enterprise Linux CoreOS (RHCOS).

NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

18 Provide the contents of the certificate file that you used for your mirror registry.

19 Provide the **imageContentSources** section from the output of the command to mirror the repository.

21.8.10.2. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.

NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

Procedure

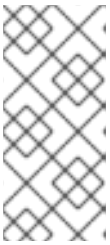
1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
```

1. A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
2. A proxy URL to use for creating HTTPS connections outside the cluster.
3. A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use ***** to bypass the proxy for all destinations. You must include vCenter's IP address and the IP range that you use for its machines.
4. If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace that contains one or more additional CA certificates that are required for proxying HTTPS connections. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges these contents with the Red Hat Enterprise Linux CoreOS (RHCOS) trust bundle, and this config map is referenced in the **trustedCA** field of the **Proxy** object. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.

NOTE

The installation program does not support the proxy **readinessEndpoints** field.



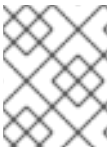
NOTE

If the installer times out, restart and then complete the deployment by using the **wait-for** command of the installer. For example:

```
$ ./openshift-install wait-for install-complete --log-level debug
```

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.



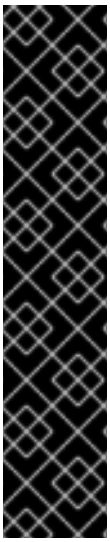
NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

21.8.11. Creating the Kubernetes manifest and Ignition config files

Because you must modify some cluster definition files and manually start the cluster machines, you must generate the Kubernetes manifest and Ignition config files that the cluster needs to configure the machines.

The installation configuration file transforms into the Kubernetes manifests. The manifests wrap into the Ignition configuration files, which are later used to configure the cluster machines.



IMPORTANT

- The Ignition config files that the OpenShift Container Platform installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

Prerequisites

- You obtained the OpenShift Container Platform installation program. For a restricted network installation, these files are on your mirror host.
- You created the **install-config.yaml** installation configuration file.

Procedure

1. Change to the directory that contains the OpenShift Container Platform installation program and generate the Kubernetes manifests for the cluster:

```
$ ./openshift-install create manifests --dir <installation_directory> 1
```

1 For **<installation_directory>**, specify the installation directory that contains the **install-config.yaml** file you created.

2. Remove the Kubernetes manifest files that define the control plane machines and compute machine sets:

```
$ rm -f openshift/99_openshift-cluster-api_master-machines-*.yaml openshift/99_openshift-cluster-api_worker-machineset-*.yaml
```

Because you create and manage these resources yourself, you do not have to initialize them.

- You can preserve the machine set files to create compute machines by using the machine API, but you must update references to them to match your environment.

3. Check that the **mastersSchedulable** parameter in the **<installation_directory>/manifests/cluster-scheduler-02-config.yml** Kubernetes manifest file is set to **false**. This setting prevents pods from being scheduled on the control plane machines:

   a. Open the **<installation_directory>/manifests/cluster-scheduler-02-config.yml** file.

   b. Locate the **mastersSchedulable** parameter and ensure that it is set to **false**.

   c. Save and exit the file.

4. To create the Ignition configuration files, run the following command from the directory that contains the installation program:

```
$ ./openshift-install create ignition-configs --dir <installation_directory> 1
```

1 For **<installation_directory>**, specify the same installation directory.

Ignition config files are created for the bootstrap, control plane, and compute nodes in the installation directory. The **kubeadmin-password** and **kubeconfig** files are created in the **./<installation_directory>/auth** directory:

```
.
├── auth
│   ├── kubeadmin-password
│   └── kubeconfig
├── bootstrap.ign
├── master.ign
├── metadata.json
└── worker.ign
```

21.8.12. Configuring chrony time service

You must set the time server and related settings used by the chrony time service (**chronyd**) by modifying the contents of the **chrony.conf** file and passing those contents to your nodes as a machine config.

Procedure

1. Create a Butane config including the contents of the **chrony.conf** file. For example, to configure chrony on worker nodes, create a **99-worker-chrony.bu** file.

NOTE

See "Creating machine configs with Butane" for information about Butane.

```
variant: openshift
version: 4.11.0
metadata:
  name: 99-worker-chrony (1)
  labels:
    machineconfiguration.openshift.io/role: worker (2)
storage:
  files:
  - path: /etc/chrony.conf
    mode: 0644 (3)
    overwrite: true
    contents:
      inline: |
        pool 0.rhel.pool.ntp.org iburst (4)
        driftfile /var/lib/chrony/drift
        makestep 1.0 3
        rtcsync
        logdir /var/log/chrony
```

(1) (2) On control plane nodes, substitute **master** for **worker** in both of these locations.

(3) Specify an octal value mode for the **mode** field in the machine config file. After creating the file and applying the changes, the **mode** is converted to a decimal value. You can check the YAML file with the command **oc get mc <mc-name> -o yaml**.

(4) Specify any valid, reachable time source, such as the one provided by your DHCP server.

2. Use Butane to generate a **MachineConfig** object file, **99-worker-chrony.yaml**, containing the configuration to be delivered to the nodes:

```
$ butane 99-worker-chrony.bu -o 99-worker-chrony.yaml
```

3. Apply the configurations in one of two ways:

- If the cluster is not running yet, after you generate manifest files, add the **MachineConfig** object file to the **<installation_directory>/openshift** directory, and then continue to create the cluster.

- If the cluster is already running, apply the file:

```
$ oc apply -f ./99-worker-chrony.yaml
```

21.8.13. Extracting the infrastructure name

The Ignition config files contain a unique cluster identifier that you can use to uniquely identify your cluster in VMware vSphere. If you plan to use the cluster identifier as the name of your virtual machine folder, you must extract it.

Prerequisites

- You obtained the OpenShift Container Platform installation program and the pull secret for your cluster.
- You generated the Ignition config files for your cluster.
- You installed the **jq** package.

Procedure

- To extract and view the infrastructure name from the Ignition config file metadata, run the following command:

```
$ jq -r .infraID <installation_directory>/metadata.json 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

Example output

```
openshift-vw9j6 1
```

1 The output of this command is your cluster name and a random string.

21.8.14. Installing RHCOS and starting the OpenShift Container Platform bootstrap process

To install OpenShift Container Platform on user-provisioned infrastructure on VMware vSphere, you must install Red Hat Enterprise Linux CoreOS (RHCOS) on vSphere hosts. When you install RHCOS, you must provide the Ignition config file that was generated by the OpenShift Container Platform installation program for the type of machine you are installing. If you have configured suitable networking, DNS, and load balancing infrastructure, the OpenShift Container Platform bootstrap process begins automatically after the RHCOS machines have rebooted.

Prerequisites

- You have obtained the Ignition config files for your cluster.
- You have access to an HTTP server that you can access from your computer and that the machines that you create can access.
- You have created a vSphere cluster.

Procedure

1. Upload the bootstrap Ignition config file, which is named **<installation_directory>/bootstrap.ign**, that the installation program created to your HTTP server. Note the URL of this file.

2. Save the following secondary Ignition config file for your bootstrap node to your computer as **<installation_directory>/merge-bootstrap.ign**:

```
{
  "ignition": {
    "config": {
      "merge": [
        {
          "source": "<bootstrap_ignition_config_url>", 1
          "verification": {}
        }
      ]
    },
    "timeouts": {},
    "version": "3.2.0"
  },
  "networkd": {},
  "passwd": {},
  "storage": {},
  "systemd": {}
}
```

1 Specify the URL of the bootstrap Ignition config file that you hosted.

When you create the virtual machine (VM) for the bootstrap machine, you use this Ignition config file.

3. Locate the following Ignition config files that the installation program created:

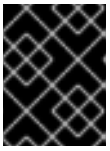
   - **<installation_directory>/master.ign**
   - **<installation_directory>/worker.ign**
   - **<installation_directory>/merge-bootstrap.ign**

4. Convert the Ignition config files to Base64 encoding. Later in this procedure, you must add these files to the extra configuration parameter **guestinfo.ignition.config.data** in your VM. For example, if you use a Linux operating system, you can use the **base64** command to encode the files.

```
$ base64 -w0 <installation_directory>/master.ign > <installation_directory>/master.64
```

```
$ base64 -w0 <installation_directory>/worker.ign > <installation_directory>/worker.64
```

```
$ base64 -w0 <installation_directory>/merge-bootstrap.ign > <installation_directory>/merge-bootstrap.64
```



IMPORTANT

If you plan to add more compute machines to your cluster after you finish installation, do not delete these files.

5. Obtain the RHCOS OVA image. Images are available from the RHCOS image mirror page.

IMPORTANT

The RHCOS images might not change with every release of OpenShift Container Platform. You must download an image with the highest version that is less than or equal to the OpenShift Container Platform version that you install. Use the image version that matches your OpenShift Container Platform version if it is available.

The filename contains the OpenShift Container Platform version number in the format **rhcos-vmware.<architecture>.ova**.

6. In the vSphere Client, create a folder in your datacenter to store your VMs.
   a. Click the **VMs and Templates** view.
   b. Right-click the name of your datacenter.
   c. Click **New Folder → New VM and Template Folder**.
   d. In the window that is displayed, enter the folder name. If you did not specify an existing folder in the **install-config.yaml** file, then create a folder with the same name as the infrastructure ID. You use this folder name so vCenter dynamically provisions storage in the appropriate location for its Workspace configuration.
7. In the vSphere Client, create a template for the OVA image and then clone the template as needed.

NOTE

In the following steps, you create a template and then clone the template for all of your cluster machines. You then provide the location for the Ignition config file for that cloned machine type when you provision the VMs.

   a. From the **Hosts and Clusters** tab, right-click your cluster name and select **Deploy OVF Template**.
   b. On the **Select an OVF** tab, specify the name of the RHCOS OVA file that you downloaded.
   c. On the **Select a name and folder** tab, set a **Virtual machine name** for your template, such as **Template-RHCOS**. Click the name of your vSphere cluster and select the folder you created in the previous step.
   d. On the **Select a compute resource** tab, click the name of your vSphere cluster.
   e. On the **Select storage** tab, configure the storage options for your VM.
      - Select **Thin Provision** or **Thick Provision**, based on your storage preferences.

- Select the datastore that you specified in your **install-config.yaml** file.

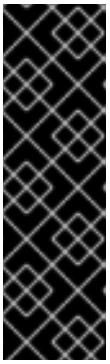
f. On the **Select network** tab, specify the network that you configured for the cluster, if available.

g. When creating the OVF template, do not specify values on the **Customize template** tab or configure the template any further.

IMPORTANT

Do not start the original VM template. The VM template must remain off and must be cloned for new RHCOS machines. Starting the VM template configures the VM template as a VM on the platform, which prevents it from being used as a template that machine sets can apply configurations to.

8. Optional: Update the configured virtual hardware version in the VM template, if necessary. Follow Upgrading a virtual machine to the latest hardware version in the VMware documentation for more information.



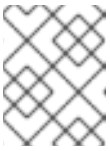
IMPORTANT

It is recommended that you update the hardware version of the VM template to version 15 before creating VMs from it, if necessary. Using hardware version 13 for your cluster nodes running on vSphere is now deprecated. If your imported template defaults to hardware version 13, you must ensure that your ESXi host is on 6.7U3 or later before upgrading the VM template to hardware version 15. If your vSphere version is less than 6.7U3, you can skip this upgrade step; however, a future version of OpenShift Container Platform is scheduled to remove support for hardware version 13 and vSphere versions less than 6.7U3.

9. After the template deploys, deploy a VM for a machine in the cluster.

a. Right-click the template name and click **Clone → Clone to Virtual Machine**

b. On the **Select a name and folder** tab, specify a name for the VM. You might include the machine type in the name, such as **control-plane-0** or **compute-1**.



NOTE

Ensure that all virtual machine names across a vSphere installation are unique.

c. On the **Select a name and folder** tab, select the name of the folder that you created for the cluster.

d. On the **Select a compute resource** tab, select the name of a host in your datacenter.

e. On the **Select clone options**, select **Customize this virtual machine's hardware**.

f. Optional: On the **Customize hardware** tab, click **VM Options → Advanced**.

IMPORTANT

The following configuration suggestions are for example purposes only. As a cluster administrator, you must configure resources according to the resource demands placed on your cluster. To best manage cluster resources, consider creating a resource pool from the cluster's root resource pool.

- Override default DHCP networking in vSphere. To enable static IP networking:
  - Set your static IP configuration:

```
$ export IPCFG="ip=<ip>::<gateway>:<netmask>:<hostname>:<iface>:none
nameserver=srv1 [nameserver=srv2 [nameserver=srv3 [...]]]"
```

Example command

```
$ export IPCFG="ip=192.168.100.101::192.168.100.254:255.255.255.0:::none
nameserver=8.8.8.8"
```

- Click **Edit Configuration**, and on the **Configuration Parameters** window, search the list of available parameters for steal clock accounting (**stealclock.enable**). Set the parameter to the value of **TRUE**. Enabling steal clock accounting can help with troubleshooting cluster issues.
- Click **Add Configuration Params**. Define the following parameter names and values:
  - **disk.EnableUUID**: Specify **TRUE**.
  - **stealclock.enable**: If this parameter was not defined, add it and specify **TRUE**.
  - Create a child resource pool from the cluster's root resource pool. Perform resource allocation in this child resource pool.

g. In the **Virtual Hardware** panel of the **Customize hardware** tab, modify the specified values as required. Ensure that the amount of RAM, CPU, and disk storage meets the minimum requirements for the machine type.

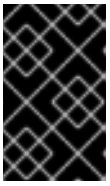
h. Complete the configuration and power on the VM.

i. Check the console output to verify that Ignition ran.

Example command

```
Ignition: ran on 2022/03/14 14:48:33 UTC (this boot)
Ignition: user-provided config was applied
```

10. Create the rest of the machines for your cluster by following the preceding steps for each machine.



IMPORTANT

You must create the bootstrap and control plane machines at this time. Because some pods are deployed on compute machines by default, also create at least two compute machines before you install the cluster.

21.8.15. Adding more compute machines to a cluster in vSphere

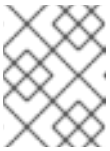
You can add more compute machines to a user-provisioned OpenShift Container Platform cluster on VMware vSphere.

Prerequisites

- Obtain the base64-encoded Ignition file for your compute machines.
- You have access to the vSphere template that you created for your cluster.

Procedure

1. After the template deploys, deploy a VM for a machine in the cluster.
   a. Right-click the template's name and click **Clone → Clone to Virtual Machine**
   b. On the **Select a name and folder** tab, specify a name for the VM. You might include the machine type in the name, such as **compute-1**.

      NOTE

      Ensure that all virtual machine names across a vSphere installation are unique.

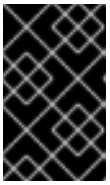
   c. On the **Select a name and folder** tab, select the name of the folder that you created for the cluster.
   d. On the **Select a compute resource** tab, select the name of a host in your datacenter.
   e. On the **Select clone options**, select **Customize this virtual machine's hardware**.
   f. On the **Customize hardware** tab, click **VM Options → Advanced**.
      - Click **Edit Configuration**, and on the **Configuration Parameters** window, click **Add Configuration Params**. Define the following parameter names and values:
        - **guestinfo.ignition.config.data**: Paste the contents of the base64-encoded compute Ignition config file for this machine type.
        - **guestinfo.ignition.config.data.encoding**: Specify **base64**.
        - **disk.EnableUUID**: Specify **TRUE**.
   g. In the **Virtual Hardware** panel of the **Customize hardware** tab, modify the specified values as required. Ensure that the amount of RAM, CPU, and disk storage meets the minimum requirements for the machine type. Also, make sure to select the correct network under **Add network adapter** if there are multiple networks available.
   h. Complete the configuration and power on the VM.
2. Continue to create more compute machines for your cluster.

21.8.16. Disk partitioning

In most cases, data partitions are originally created by installing RHCOS, rather than by installing another operating system. In such cases, the OpenShift Container Platform installer should be allowed to configure your disk partitions.

However, there are two cases where you might want to intervene to override the default partitioning when installing an OpenShift Container Platform node:

- Create separate partitions: For greenfield installations on an empty disk, you might want to add separate storage to a partition. This is officially supported for making **/var** or a subdirectory of **/var**, such as **/var/lib/etcd**, a separate partition, but not both.



IMPORTANT

For disk sizes larger than 100GB, and especially disk sizes larger than 1TB, create a separate **/var** partition. See "Creating a separate **/var** partition" and this Red Hat Knowledgebase article for more information.

IMPORTANT

Kubernetes supports only two file system partitions. If you add more than one partition to the original configuration, Kubernetes cannot monitor all of them.

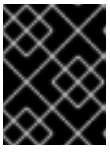
- Retain existing partitions: For a brownfield installation where you are reinstalling OpenShift Container Platform on an existing node and want to retain data partitions installed from your previous operating system, there are both boot arguments and options to **coreos-installer** that allow you to retain existing data partitions.

Creating a separate /var partition

In general, disk partitioning for OpenShift Container Platform should be left to the installer. However, there are cases where you might want to create separate partitions in a part of the filesystem that you expect to grow.

OpenShift Container Platform supports the addition of a single partition to attach storage to either the **/var** partition or a subdirectory of **/var**. For example:

- **/var/lib/containers**: Holds container-related content that can grow as more images and containers are added to a system.
- **/var/lib/etcd**: Holds data that you might want to keep separate for purposes such as performance optimization of etcd storage.
- **/var**: Holds data that you might want to keep separate for purposes such as auditing.



IMPORTANT

For disk sizes larger than 100GB, and especially larger than 1TB, create a separate **/var** partition.

Storing the contents of a **/var** directory separately makes it easier to grow storage for those areas as needed and reinstall OpenShift Container Platform at a later date and keep that data intact. With this method, you will not have to pull all your containers again, nor will you have to copy massive log files when you update systems.

Because **/var** must be in place before a fresh installation of Red Hat Enterprise Linux CoreOS (RHCOS), the following procedure sets up the separate **/var** partition by creating a machine config manifest that is

inserted during the **openshift-install** preparation phases of an OpenShift Container Platform installation.

Procedure

1. Create a directory to hold the OpenShift Container Platform installation files:

```
$ mkdir $HOME/clusterconfig
```

2. Run **openshift-install** to create a set of files in the **manifest** and **openshift** subdirectories. Answer the system questions as you are prompted:

```
$ openshift-install create manifests --dir $HOME/clusterconfig
? SSH Public Key ...
$ ls $HOME/clusterconfig/openshift/
99_kubeadmin-password-secret.yaml
99_openshift-cluster-api_master-machines-0.yaml
99_openshift-cluster-api_master-machines-1.yaml
99_openshift-cluster-api_master-machines-2.yaml
...
```

3. Create a Butane config that configures the additional partition. For example, name the file **$HOME/clusterconfig/98-var-partition.bu**, change the disk device name to the name of the storage device on the **worker** systems, and set the storage size as appropriate. This example places the **/var** directory on a separate partition:

```
variant: openshift
version: 4.11.0
metadata:
  labels:
    machineconfiguration.openshift.io/role: worker
  name: 98-var-partition
storage:
  disks:
  - device: /dev/<device_name> 1
    partitions:
    - label: var
      start_mib: <partition_start_offset> 2
      size_mib: <partition_size> 3
  filesystems:
    - device: /dev/disk/by-partlabel/var
      path: /var
      format: xfs
      mount_options: [defaults, prjquota] 4
      with_mount_unit: true
```

1. The storage device name of the disk that you want to partition.
2. When adding a data partition to the boot disk, a minimum value of 25000 mebibytes is recommended. The root file system is automatically resized to fill all available space up to the specified offset. If no value is specified, or if the specified value is smaller than the recommended minimum, the resulting root file system will be too small, and future reinstalls of RHCOS might overwrite the beginning of the data partition.

3 The size of the data partition in mebibytes.

4 The **prjquota** mount option must be enabled for filesystems used for container storage.

NOTE

When creating a separate /**var** partition, you cannot use different instance types for worker nodes, if the different instance types do not have the same device name.

4. Create a manifest from the Butane config and save it to the **clusterconfig/openshift** directory. For example, run the following command:

```
$ butane $HOME/clusterconfig/98-var-partition.bu -o $HOME/clusterconfig/openshift/98-var-partition.yaml
```

5. Run **openshift-install** again to create Ignition configs from a set of files in the **manifest** and **openshift** subdirectories:

```
$ openshift-install create ignition-configs --dir $HOME/clusterconfig
$ ls $HOME/clusterconfig/
auth  bootstrap.ign  master.ign  metadata.json  worker.ign
```

Now you can use the Ignition config files as input to the vSphere installation procedures to install Red Hat Enterprise Linux CoreOS (RHCOS) systems.

21.8.17. Updating the bootloader using bootupd

To update the bootloader by using **bootupd**, you must either install **bootupd** on RHCOS machines manually or provide a machine config with the enabled **systemd** unit. Unlike **grubby** or other bootloader tools, **bootupd** does not manage kernel space configuration such as passing kernel arguments.

After you have installed **bootupd**, you can manage it remotely from the OpenShift Container Platform cluster.

NOTE

It is recommended that you use **bootupd** only on bare metal or virtualized hypervisor installations, such as for protection against the BootHole vulnerability.

Manual install method

You can manually install **bootupd** by using the **bootctl** command-line tool.

1. Inspect the system status:

```
# bootupctl status
```

Example output for x86_64

```
Component EFI
  Installed: grub2-efi-x64-1:2.04-31.fc33.x86_64,shim-x64-15-8.x86_64
  Update: At latest version
```

Example output for aarch64

```
Component EFI
  Installed: grub2-efi-aa64-1:2.02-99.el8_4.1.aarch64,shim-aa64-15.4-2.el8_1.aarch64
  Update: At latest version
```

2. RHCOS images created without **bootupd** installed on them require an explicit adoption phase. If the system status is **Adoptable**, perform the adoption:

```
# bootupctl adopt-and-update
```

Example output

```
Updated: grub2-efi-x64-1:2.04-31.fc33.x86_64,shim-x64-15-8.x86_64
```

3. If an update is available, apply the update so that the changes take effect on the next reboot:

```
# bootupctl update
```

Example output

```
Updated: grub2-efi-x64-1:2.04-31.fc33.x86_64,shim-x64-15-8.x86_64
```

Machine config method

Another way to enable **bootupd** is by providing a machine config.

- Provide a machine config file with the enabled **systemd** unit, as shown in the following example:

Example output

```
variant: rhcos
version: 1.1.0
systemd:
  units:
    - name: custom-bootupd-auto.service
      enabled: true
      contents: |
        [Unit]
        Description=Bootupd automatic update

        [Service]
        ExecStart=/usr/bin/bootupctl update
        RemainAfterExit=yes

        [Install]
        WantedBy=multi-user.target
```

21.8.18. Waiting for the bootstrap process to complete

The OpenShift Container Platform bootstrap process begins after the cluster nodes first boot into the persistent RHCOS environment that has been installed to disk. The configuration information provided through the Ignition config files is used to initialize the bootstrap process and install OpenShift Container Platform on the machines. You must wait for the bootstrap process to complete.

Prerequisites

- You have created the Ignition config files for your cluster.
- You have configured suitable network, DNS and load balancing infrastructure.
- You have obtained the installation program and generated the Ignition config files for your cluster.
- You installed RHCOS on your cluster machines and provided the Ignition config files that the OpenShift Container Platform installation program generated.

Procedure

1. Monitor the bootstrap process:

```
$ ./openshift-install --dir <installation_directory> wait-for bootstrap-complete \ 1
    --log-level=info 2
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

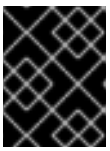
2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

Example output

```
INFO Waiting up to 30m0s for the Kubernetes API at https://api.test.example.com:6443...
INFO API v1.24.0 up
INFO Waiting up to 30m0s for bootstrapping to complete...
INFO It is now safe to remove the bootstrap resources
```

The command succeeds when the Kubernetes API server signals that it has been bootstrapped on the control plane machines.

2. After the bootstrap process is complete, remove the bootstrap machine from the load balancer.



IMPORTANT

You must remove the bootstrap machine from the load balancer at this point. You can also remove or reformat the bootstrap machine itself.

21.8.19. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container

Platform installation.

Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

Example output

```
system:admin
```

21.8.20. Approving the certificate signing requests for your machines

When you add machines to a cluster, two pending certificate signing requests (CSRs) are generated for each machine that you added. You must confirm that these CSRs are approved or, if necessary, approve them yourself. The client requests must be approved first, followed by the server requests.

Prerequisites

- You added machines to your cluster.

Procedure

1. Confirm that the cluster recognizes the machines:

```
$ oc get nodes
```

Example output

```
NAME     STATUS   ROLES   AGE  VERSION
master-0 Ready    master  63m  v1.24.0
master-1 Ready    master  63m  v1.24.0
master-2 Ready    master  64m  v1.24.0
```

The output lists all of the machines that you created.

NOTE

The preceding output might not include the compute nodes, also known as worker nodes, until some CSRs are approved.

2. Review the pending CSRs and ensure that you see the client requests with the **Pending** or **Approved** status for each machine that you added to the cluster:

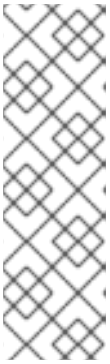
```
$ oc get csr
```

Example output

```
NAME        AGE    REQUESTOR                                                   CONDITION
csr-8b2br   15m    system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper   Pending
csr-8vnps   15m    system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper   Pending
...
```

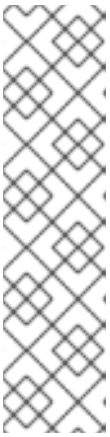
In this example, two machines are joining the cluster. You might see more approved CSRs in the list.

3. If the CSRs were not approved, after all of the pending CSRs for the machines you added are in **Pending** status, approve the CSRs for your cluster machines:



NOTE

Because the CSRs rotate automatically, approve your CSRs within an hour of adding the machines to the cluster. If you do not approve them within an hour, the certificates will rotate, and more than two certificates will be present for each node. You must approve all of these certificates. After the client CSR is approved, the Kubelet creates a secondary CSR for the serving certificate, which requires manual approval. Then, subsequent serving certificate renewal requests are automatically approved by the **machine-approver** if the Kubelet requests a new certificate with identical parameters.



NOTE

For clusters running on platforms that are not machine API enabled, such as bare metal and other user-provisioned infrastructure, you must implement a method of automatically approving the kubelet serving certificate requests (CSRs). If a request is not approved, then the **oc exec**, **oc rsh**, and **oc logs** commands cannot succeed, because a serving certificate is required when the API server connects to the kubelet. Any operation that contacts the Kubelet endpoint requires this certificate approval to be in place. The method must watch for new CSRs, confirm that the CSR was submitted by the **node-bootstrapper** service account in the **system:node** or **system:admin** groups, and confirm the identity of the node.

- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

1 **<csr_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{{"\n"}}
{{end}}{{end}}' | xargs --no-run-if-empty oc adm certificate approve
```

NOTE

Some Operators might not become available until some CSRs are approved.

4. Now that your client requests are approved, you must review the server requests for each machine that you added to the cluster:

```
$ oc get csr
```

Example output

```
NAME        AGE     REQUESTOR                                                   CONDITION
csr-bfd72   5m26s   system:node:ip-10-0-50-126.us-east-2.compute.internal
Pending
csr-c57lv   5m26s   system:node:ip-10-0-95-157.us-east-2.compute.internal
Pending
...
```

5. If the remaining CSRs are not approved, and are in the **Pending** status, approve the CSRs for your cluster machines:

- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

1 **<csr_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{{"\n"}}
{{end}}{{end}}' | xargs oc adm certificate approve
```

6. After all client and server CSRs have been approved, the machines have the **Ready** status. Verify this by running the following command:

```
$ oc get nodes
```

Example output

```
NAME      STATUS    ROLES   AGE  VERSION
master-0  Ready     master  73m  v1.24.0
master-1  Ready     master  73m  v1.24.0
```

```
master-2  Ready    master  74m  v1.24.0
worker-0  Ready    worker  11m  v1.24.0
worker-1  Ready    worker  11m  v1.24.0
```

NOTE

It can take a few minutes after approval of the server CSRs for the machines to transition to the **Ready** status.

Additional information

- For more information on CSRs, see Certificate Signing Requests.

21.8.21. Initial Operator configuration

After the control plane initializes, you must immediately configure some Operators so that they all become available.

Prerequisites

- Your control plane has initialized.

Procedure

1. Watch the cluster components come online:

```
$ watch -n5 oc get clusteroperators
```

Example output

```
NAME                                       VERSION   AVAILABLE   PROGRESSING   DEGRADED
SINCE
authentication                             4.11.0    True        False         False      19m
baremetal                                  4.11.0    True        False         False      37m
cloud-credential                           4.11.0    True        False         False      40m
cluster-autoscaler                         4.11.0    True        False         False      37m
config-operator                            4.11.0    True        False         False      38m
console                                    4.11.0    True        False         False      26m
csi-snapshot-controller                    4.11.0    True        False         False      37m
dns                                        4.11.0    True        False         False      37m
etcd                                       4.11.0    True        False         False      36m
image-registry                             4.11.0    True        False         False      31m
ingress                                    4.11.0    True        False         False      30m
insights                                   4.11.0    True        False         False      31m
kube-apiserver                             4.11.0    True        False         False      26m
kube-controller-manager                    4.11.0    True        False         False      36m
kube-scheduler                             4.11.0    True        False         False      36m
kube-storage-version-migrator              4.11.0    True        False         False      37m
machine-api                                4.11.0    True        False         False      29m
machine-approver                           4.11.0    True        False         False      37m
machine-config                             4.11.0    True        False         False      36m
marketplace                                4.11.0    True        False         False      37m
monitoring                                 4.11.0    True        False         False      29m
network                                    4.11.0    True        False         False      38m
```

```
node-tuning                                4.11.0    True        False         False      37m
openshift-apiserver                        4.11.0    True        False         False      32m
openshift-controller-manager               4.11.0    True        False         False      30m
openshift-samples                          4.11.0    True        False         False      32m
operator-lifecycle-manager                 4.11.0    True        False         False      37m
operator-lifecycle-manager-catalog         4.11.0    True        False         False      37m
operator-lifecycle-manager-packageserver   4.11.0    True        False         False      32m
service-ca                                 4.11.0    True        False         False      38m
storage                                    4.11.0    True        False         False      37m
```

2. Configure the Operators that are not available.

21.8.21.1. Disabling the default OperatorHub sources

Operator catalogs that source content provided by Red Hat and community projects are configured for OperatorHub by default during an OpenShift Container Platform installation. In a restricted network environment, you must disable the default catalogs as a cluster administrator.

Procedure

- Disable the sources for the default catalogs by adding **disableAllDefaultSources: true** to the **OperatorHub** object:

```
$ oc patch OperatorHub cluster --type json \
    -p '[{"op": "add", "path": "/spec/disableAllDefaultSources", "value": true}]'
```

TIP

Alternatively, you can use the web console to manage catalog sources. From the **Administration → Cluster Settings → Configuration → OperatorHub** page, click the **Sources** tab, where you can create, update, delete, disable, and enable individual sources.

21.8.21.2. Image registry storage configuration

The Image Registry Operator is not initially available for platforms that do not provide default storage. After installation, you must configure your registry to use storage so that the Registry Operator is made available.

Instructions are shown for configuring a persistent volume, which is required for production clusters. Where applicable, instructions are shown for configuring an empty directory as the storage location, which is available for only non-production clusters.

Additional instructions are provided for allowing the image registry to use block storage types by using the **Recreate** rollout strategy during upgrades.

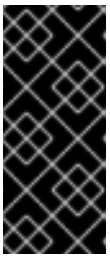
21.8.21.2.1. Configuring registry storage for VMware vSphere

As a cluster administrator, following installation you must configure your registry to use storage.

Prerequisites

- Cluster administrator permissions.
- A cluster on VMware vSphere.

- Persistent storage provisioned for your cluster, such as Red Hat OpenShift Data Foundation.



IMPORTANT

OpenShift Container Platform supports **ReadWriteOnce** access for image registry storage when you have only one replica. **ReadWriteOnce** access also requires that the registry uses the **Recreate** rollout strategy. To deploy an image registry that supports high availability with two or more replicas, **ReadWriteMany** access is required.

- Must have "100Gi" capacity.

IMPORTANT

Testing shows issues with using the NFS server on RHEL as storage backend for core services. This includes the OpenShift Container Registry and Quay, Prometheus for monitoring storage, and Elasticsearch for logging storage. Therefore, using RHEL NFS to back PVs used by core services is not recommended.

Other NFS implementations on the marketplace might not have these issues. Contact the individual NFS implementation vendor for more information on any testing that was possibly completed against these OpenShift Container Platform core components.

Procedure

1. To configure your registry to use storage, change the **spec.storage.pvc** in the **configs.imageregistry/cluster** resource.

NOTE

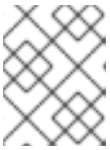
When you use shared storage, review your security settings to prevent outside access.

2. Verify that you do not have a registry pod:

```
$ oc get pod -n openshift-image-registry -l docker-registry=default
```

Example output

```
No resourses found in openshift-image-registry namespace
```



NOTE

If you do have a registry pod in your output, you do not need to continue with this procedure.

3. Check the registry configuration:

```
$ oc edit configs.imageregistry.operator.openshift.io
```

Example output

```
storage:
  pvc:
    claim: 1
```

1 Leave the **claim** field blank to allow the automatic creation of an **image-registry-storage** persistent volume claim (PVC). The PVC is generated based on the default storage class. However, be aware that the default storage class might provide ReadWriteOnce (RWO) volumes, such as a RADOS Block Device (RBD), which can cause issues when you replicate to more than one replica.

4. Check the **clusteroperator** status:

```
$ oc get clusteroperator image-registry
```

Example output

```
NAME             VERSION                             AVAILABLE   PROGRESSING   DEGRADED
SINCE   MESSAGE
image-registry   4.7                                 True        False         False      6h50m
```

21.8.21.2.2. Configuring storage for the image registry in non-production clusters

You must configure storage for the Image Registry Operator. For non-production clusters, you can set the image registry to an empty directory. If you do so, all images are lost if you restart the registry.

Procedure

- To set the image registry storage to an empty directory:

```
$ oc patch configs.imageregistry.operator.openshift.io cluster --type merge --patch '{"spec":
{"storage":{"emptyDir":{}}}}'
```

WARNING

Configure this option for only non-production clusters.

If you run this command before the Image Registry Operator initializes its components, the **oc patch** command fails with the following error:

```
Error from server (NotFound): configs.imageregistry.operator.openshift.io "cluster" not found
```

Wait a few minutes and run the command again.

21.8.21.2.3. Configuring block registry storage for VMware vSphere

To allow the image registry to use block storage types such as vSphere Virtual Machine Disk (VMDK) during upgrades as a cluster administrator, you can use the **Recreate** rollout strategy.

IMPORTANT

Block storage volumes are supported but not recommended for use with image registry on production clusters. An installation where the registry is configured on block storage is not highly available because the registry cannot have more than one replica.

Procedure

1. Enter the following command to set the image registry storage as a block storage type, patch the registry so that it uses the **Recreate** rollout strategy, and runs with only **1** replica:

```
$ oc patch config.imageregistry.operator.openshift.io/cluster --type=merge -p '{"spec":
{"rolloutStrategy":"Recreate","replicas":1}}'
```

2. Provision the PV for the block storage device, and create a PVC for that volume. The requested block volume uses the ReadWriteOnce (RWO) access mode.

   a. Create a **pvc.yaml** file with the following contents to define a VMware vSphere **PersistentVolumeClaim** object:

```
kind: PersistentVolumeClaim
apiVersion: v1
metadata:
  name: image-registry-storage 1
  namespace: openshift-image-registry 2
spec:
  accessModes:
  - ReadWriteOnce 3
  resources:
    requests:
      storage: 100Gi 4
```

   1. A unique name that represents the **PersistentVolumeClaim** object.
   2. The namespace for the **PersistentVolumeClaim** object, which is **openshift-image-registry**.
   3. The access mode of the persistent volume claim. With **ReadWriteOnce**, the volume can be mounted with read and write permissions by a single node.
   4. The size of the persistent volume claim.

   b. Enter the following command to create the **PersistentVolumeClaim** object from the file:

```
$ oc create -f pvc.yaml -n openshift-image-registry
```

3. Enter the following command to edit the registry configuration so that it references the correct PVC:

```
$ oc edit config.imageregistry.operator.openshift.io -o yaml
```

Example output

```
storage:
  pvc:
    claim: 1
```

1 By creating a custom PVC, you can leave the **claim** field blank for the default automatic creation of an **image-registry-storage** PVC.

For instructions about configuring registry storage so that it references the correct PVC, see Configuring the registry for vSphere.

21.8.22. Completing installation on user-provisioned infrastructure

After you complete the Operator configuration, you can finish installing the cluster on infrastructure that you provide.

Prerequisites

- Your control plane has initialized.
- You have completed the initial Operator configuration.

Procedure

1. Confirm that all the cluster components are online with the following command:

```
$ watch -n5 oc get clusteroperators
```

Example output

```
NAME                                       VERSION   AVAILABLE   PROGRESSING   DEGRADED
SINCE
authentication                             4.11.0    True        False         False      19m
baremetal                                  4.11.0    True        False         False      37m
cloud-credential                           4.11.0    True        False         False      40m
cluster-autoscaler                         4.11.0    True        False         False      37m
config-operator                            4.11.0    True        False         False      38m
console                                    4.11.0    True        False         False      26m
csi-snapshot-controller                    4.11.0    True        False         False      37m
dns                                        4.11.0    True        False         False      37m
etcd                                       4.11.0    True        False         False      36m
image-registry                             4.11.0    True        False         False      31m
ingress                                    4.11.0    True        False         False      30m
insights                                   4.11.0    True        False         False      31m
kube-apiserver                             4.11.0    True        False         False      26m
kube-controller-manager                    4.11.0    True        False         False      36m
kube-scheduler                             4.11.0    True        False         False      36m
kube-storage-version-migrator              4.11.0    True        False         False      37m
machine-api                                4.11.0    True        False         False      29m
machine-approver                           4.11.0    True        False         False      37m
machine-config                             4.11.0    True        False         False      36m
marketplace                                4.11.0    True        False         False      37m
monitoring                                 4.11.0    True        False         False      29m
network                                    4.11.0    True        False         False      38m
```

```
node-tuning                                4.11.0    True        False         False      37m
openshift-apiserver                        4.11.0    True        False         False      32m
openshift-controller-manager               4.11.0    True        False         False      30m
openshift-samples                          4.11.0    True        False         False      32m
operator-lifecycle-manager                 4.11.0    True        False         False      37m
operator-lifecycle-manager-catalog         4.11.0    True        False         False      37m
operator-lifecycle-manager-packageserver   4.11.0    True        False         False      32m
service-ca                                 4.11.0    True        False         False      38m
storage                                    4.11.0    True        False         False      37m
```

Alternatively, the following command notifies you when all of the clusters are available. It also retrieves and displays credentials:

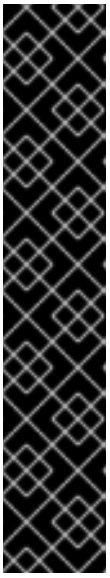
```
$ ./openshift-install --dir <installation_directory> wait-for install-complete 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

Example output

```
INFO Waiting up to 30m0s for the cluster to initialize...
```

The command succeeds when the Cluster Version Operator finishes deploying the OpenShift Container Platform cluster from Kubernetes API server.



IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

2. Confirm that the Kubernetes API server is communicating with the pods.
   a. To view a list of all pods, use the following command:

```
$ oc get pods --all-namespaces
```

Example output

```
NAMESPACE                       NAME                                         READY   STATUS
RESTARTS   AGE
openshift-apiserver-operator    openshift-apiserver-operator-85cb746d55-zqhs8   1/1
```

```
Running     1          9m
openshift-apiserver             apiserver-67b9g                              1/1     Running     0
3m
openshift-apiserver             apiserver-ljcmx                              1/1     Running     0
1m
openshift-apiserver             apiserver-z25h4                              1/1     Running     0
2m
openshift-authentication-operator authentication-operator-69d5d8bf84-vh2n8       1/1
Running     0          5m
...
```

b. View the logs for a pod that is listed in the output of the previous command by using the following command:

```
$ oc logs <pod_name> -n <namespace> 1
```

1 Specify the pod name and namespace, as shown in the output of the previous command.

If the pod logs display, the Kubernetes API server can communicate with the cluster machines.

3. For an installation with Fibre Channel Protocol (FCP), additional steps are required to enable multipathing. Do not enable multipathing during installation.
See "Enabling multipathing with kernel arguments on RHCOS" in the *Post-installation machine configuration tasks* documentation for more information.

4. Register your cluster on the Cluster registration page.

You can add extra compute machines after the cluster installation is completed by following Adding compute machines to vSphere.

21.8.23. Configuring vSphere DRS anti-affinity rules for control plane nodes

vSphere Distributed Resource Scheduler (DRS) anti-affinity rules can be configured to support higher availability of OpenShift Container Platform control plane nodes. Anti-affinity rules ensure that the vSphere Virtual Machines for the OpenShift Container Platform control plane nodes are not scheduled to the same vSphere Host.

IMPORTANT

- The following information applies to compute DRS only and does not apply to storage DRS.
- The **govc**` command is an open-source command available from VMware; it is not available from Red Hat. The **govc** command is not supported by the Red Hat support.
- Instructions for downloading and installing **govc** are found on the VMware documentation website.

Create an anti-affinity rule by running the following command:

Example command

```
$ govc cluster.rule.create \
  -name openshift4-control-plane-group \
  -dc MyDatacenter -cluster MyCluster \
  -enable \
  -anti-affinity master-0 master-1 master-2
```

After creating the rule, your control plane nodes are automatically migrated by vSphere so they are not running on the same hosts. This might take some time while vSphere reconciles the new rule. Successful command completion is shown in the following procedure.

NOTE

The migration occurs automatically and might cause brief OpenShift API outage or latency until the migration finishes.

The vSphere DRS anti-affinity rules need to be updated manually in the event of a control plane VM name change or migration to a new vSphere Cluster.

Procedure

1. Remove any existing DRS anti-affinity rule by running the following command:

```
$ govc cluster.rule.remove \
  -name openshift4-control-plane-group \
  -dc MyDatacenter -cluster MyCluster
```

Example Output

```
[13-10-22 09:33:24] Reconfigure /MyDatacenter/host/MyCluster...OK
```

2. Create the rule again with updated names by running the following command:

```
$ govc cluster.rule.create \
  -name openshift4-control-plane-group \
  -dc MyDatacenter -cluster MyOtherCluster \
  -enable \
  -anti-affinity master-0 master-1 master-2
```

21.8.24. Backing up VMware vSphere volumes

OpenShift Container Platform provisions new volumes as independent persistent disks to freely attach and detach the volume on any node in the cluster. As a consequence, it is not possible to back up volumes that use snapshots, or to restore volumes from snapshots. See Snapshot Limitations for more information.

Procedure

To create a backup of persistent volumes:

1. Stop the application that is using the persistent volume.

2. Clone the persistent volume.

3. Restart the application.
4. Create a backup of the cloned volume.
5. Delete the cloned volume.

21.8.25. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.11, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to OpenShift Cluster Manager Hybrid Cloud Console.

After you confirm that your OpenShift Cluster Manager Hybrid Cloud Console inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, use subscription watch to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

Additional resources

- See About remote health monitoring for more information about the Telemetry service

21.8.26. Next steps

- Customize your cluster.
- If the mirror registry that you used to install your cluster has a trusted CA, add it to the cluster by configuring additional trust stores.
- If necessary, you can opt out of remote health reporting .
- Optional: View the events from the vSphere Problem Detector Operator to determine if the cluster has permission or storage configuration issues.

21.9. UNINSTALLING A CLUSTER ON VSPHERE THAT USES INSTALLER-PROVISIONED INFRASTRUCTURE

You can remove a cluster that you deployed in your VMware vSphere instance by using installer-provisioned infrastructure.

NOTE

When you run the **openshift-install destroy cluster** command to uninstall OpenShift Container Platform, vSphere volumes are not automatically deleted. The cluster administrator must manually find the vSphere volumes and delete them.

21.9.1. Removing a cluster that uses installer-provisioned infrastructure

You can remove a cluster that uses installer-provisioned infrastructure from your cloud.

NOTE

After uninstallation, check your cloud provider for any resources not removed properly, especially with User Provisioned Infrastructure (UPI) clusters. There might be resources that the installer did not create or that the installer is unable to access.

Prerequisites

- You have a copy of the installation program that you used to deploy the cluster.
- You have the files that the installation program generated when you created your cluster.

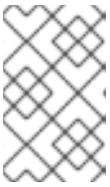
Procedure

1. On the computer that you used to install the cluster, go to the directory that contains the installation program, and run the following command:

```
$ ./openshift-install destroy cluster \
--dir <installation_directory> --log-level info 1 2
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2 To view different details, specify **warn**, **debug**, or **error** instead of **info**.



NOTE

You must specify the directory that contains the cluster definition files for your cluster. The installation program requires the **metadata.json** file in this directory to delete the cluster.

2. Optional: Delete the **<installation_directory>** directory and the OpenShift Container Platform installation program.

21.10. USING THE VSPHERE PROBLEM DETECTOR OPERATOR

21.10.1. About the vSphere Problem Detector Operator

The vSphere Problem Detector Operator checks clusters that are deployed on vSphere for common installation and misconfiguration issues that are related to storage.

The Operator runs in the **openshift-cluster-storage-operator** namespace and is started by the Cluster Storage Operator when the Cluster Storage Operator detects that the cluster is deployed on vSphere. The vSphere Problem Detector Operator communicates with the vSphere vCenter Server to determine the virtual machines in the cluster, the default datastore, and other information about the vSphere vCenter Server configuration. The Operator uses the credentials from the Cloud Credential Operator to connect to vSphere.

The Operator runs the checks according to the following schedule:

- The checks run every 8 hours.

- If any check fails, the Operator runs the checks again in intervals of 1 minute, 2 minutes, 4, 8, and so on. The Operator doubles the interval up to a maximum interval of 8 hours.
- When all checks pass, the schedule returns to an 8 hour interval.

The Operator increases the frequency of the checks after a failure so that the Operator can report success quickly after the failure condition is remedied. You can run the Operator manually for immediate troubleshooting information.

21.10.2. Running the vSphere Problem Detector Operator checks

You can override the schedule for running the vSphere Problem Detector Operator checks and run the checks immediately.

The vSphere Problem Detector Operator automatically runs the checks every 8 hours. However, when the Operator starts, it runs the checks immediately. The Operator is started by the Cluster Storage Operator when the Cluster Storage Operator starts and determines that the cluster is running on vSphere. To run the checks immediately, you can scale the vSphere Problem Detector Operator to **0** and back to **1** so that it restarts the vSphere Problem Detector Operator.

Prerequisites

- Access to the cluster as a user with the **cluster-admin** role.

Procedure

1. Scale the Operator to **0**:

```
$ oc scale deployment/vsphere-problem-detector-operator --replicas=0 \
    -n openshift-cluster-storage-operator
```

   If the deployment does not scale to zero immediately, you can run the following command to wait for the pods to exit:

```
$ oc wait pods -l name=vsphere-problem-detector-operator \
    --for=delete --timeout=5m -n openshift-cluster-storage-operator
```

2. Scale the Operator back to **1**:

```
$ oc scale deployment/vsphere-problem-detector-operator --replicas=1 \
    -n openshift-cluster-storage-operator
```

3. Delete the old leader lock to speed up the new leader election for the Cluster Storage Operator:

```
$ oc delete -n openshift-cluster-storage-operator \
    cm vsphere-problem-detector-lock
```

Verification

- View the events or logs that are generated by the vSphere Problem Detector Operator. Confirm that the events or logs have recent timestamps.

21.10.3. Viewing the events from the vSphere Problem Detector Operator

After the vSphere Problem Detector Operator runs and performs the configuration checks, it creates events that can be viewed from the command line or from the OpenShift Container Platform web console.

Procedure

- To view the events by using the command line, run the following command:

```
$ oc get event -n openshift-cluster-storage-operator \
    --sort-by={.metadata.creationTimestamp}
```

Example output

```
16m     Normal   Started                pod/vsphere-problem-detector-operator-xxxxx      Started
container vsphere-problem-detector
16m     Normal   Created                pod/vsphere-problem-detector-operator-xxxxx      Created
container vsphere-problem-detector
16m     Normal   LeaderElection         configmap/vsphere-problem-detector-lock  vsphere-
problem-detector-operator-xxxxx became leader
```

- To view the events by using the OpenShift Container Platform web console, navigate to **Home → Events** and select **openshift-cluster-storage-operator** from the **Project** menu.

21.10.4. Viewing the logs from the vSphere Problem Detector Operator

After the vSphere Problem Detector Operator runs and performs the configuration checks, it creates log records that can be viewed from the command line or from the OpenShift Container Platform web console.

Procedure

- To view the logs by using the command line, run the following command:

```
$ oc logs deployment/vsphere-problem-detector-operator \
    -n openshift-cluster-storage-operator
```

Example output

```
I0108 08:32:28.445696       1 operator.go:209] ClusterInfo passed
I0108 08:32:28.451029       1 datastore.go:57] CheckStorageClasses checked 1 storage
classes, 0 problems found
I0108 08:32:28.451047       1 operator.go:209] CheckStorageClasses passed
I0108 08:32:28.452160       1 operator.go:209] CheckDefaultDatastore passed
I0108 08:32:28.480648       1 operator.go:271] CheckNodeDiskUUID:<host_name> passed
I0108 08:32:28.480685       1 operator.go:271] CheckNodeProviderID:<host_name> passed
```

- To view the Operator logs with the OpenShift Container Platform web console, perform the following steps:

  a. Navigate to **Workloads → Pods**.

  b. Select **openshift-cluster-storage-operator** from the **Projects** menu.

  c. Click the link for the **vsphere-problem-detector-operator** pod.

d. Click the **Logs** tab on the **Pod details** page to view the logs.

21.10.5. Configuration checks run by the vSphere Problem Detector Operator

The following tables identify the configuration checks that the vSphere Problem Detector Operator runs. Some checks verify the configuration of the cluster. Other checks verify the configuration of each node in the cluster.

Table 21.86. Cluster configuration checks

Name	Description
CheckDefaultDatastore	Verifies that the default datastore name in the vSphere configuration is short enough for use with dynamic provisioning. If this check fails, you can expect the following: ● **systemd** logs errors to the journal such as**Failed to set up mount unit: Invalid argument**. ● **systemd** does not unmount volumes if the virtual machine is shut down or rebooted without draining all the pods from the node. If this check fails, reconfigure vSphere with a shorter name for the default datastore.
CheckFolderPermissions	Verifies the permission to list volumes in the default datastore. This permission is required to create volumes. The Operator verifies the permission by listing the / and **/kubevols** directories. The root directory must exist. It is acceptable if the **/kubevols** directory does not exist when the check runs. The **/kubevols** directory is created when the datastore is used with dynamic provisioning if the directory does not already exist. If this check fails, review the required permissions for the vCenter account that was specified during the OpenShift Container Platform installation.
CheckStorageClasses	Verifies the following: ● The fully qualified path to each persistent volume that is provisioned by this storage class is less than 255 characters. ● If a storage class uses a storage policy, the storage class must use one policy only and that policy must be defined.
CheckTaskPermissions	Verifies the permission to list recent tasks and datastores.
ClusterInfo	Collects the cluster version and UUID from vSphere vCenter.

Table 21.87. Node configuration checks

Name	Description

Name	Description
CheckNodeDiskUUID	Verifies that all the vSphere virtual machines are configured with **disk.enableUUID=TRUE**. If this check fails, see the How to check 'disk.EnableUUID' parameter from VM in vSphere Red Hat Knowledgebase solution.
CheckNodeProviderID	Verifies that all nodes are configured with the **ProviderID** from vSphere vCenter. This check fails when the output from the following command does not include a provider ID for each node. `$ oc get nodes -o custom-columns=NAME:.metadata.name,PROVIDER_ID:.spec.providerID,UUID:.status.nodeInfo.systemUUID` If this check fails, refer to the vSphere product documentation for information about setting the provider ID for each node in the cluster.
CollectNodeESXiVersion	Reports the version of the ESXi hosts that run nodes.
CollectNodeHWVersion	Reports the virtual machine hardware version for a node.

21.10.6. About the storage class configuration check

The names for persistent volumes that use vSphere storage are related to the datastore name and cluster ID.

When a persistent volume is created, **systemd** creates a mount unit for the persistent volume. The **systemd** process has a 255 character limit for the length of the fully qualified path to the VDMK file that is used for the persistent volume.

The fully qualified path is based on the naming conventions for **systemd** and vSphere. The naming conventions use the following pattern:

```
/var/lib/kubelet/plugins/kubernetes.io/vsphere-volume/mounts/[<datastore>] 00000000-0000-0000-0000-000000000000/<cluster_id>-dynamic-pvc-00000000-0000-0000-0000-000000000000.vmdk
```

- The naming conventions require 205 characters of the 255 character limit.
- The datastore name and the cluster ID are determined from the deployment.
- The datastore name and cluster ID are substituted into the preceding pattern. Then the path is processed with the **systemd-escape** command to escape special characters. For example, a hyphen character uses four characters after it is escaped. The escaped value is **\x2d**.
- After processing with **systemd-escape** to ensure that **systemd** can access the fully qualified path to the VDMK file, the length of the path must be less than 255 characters.

21.10.7. Metrics for the vSphere Problem Detector Operator

The vSphere Problem Detector Operator exposes the following metrics for use by the OpenShift Container Platform monitoring stack.

Table 21.88. Metrics exposed by the vSphere Problem Detector Operator

Name	Description
vsphere_cluster_check_total	Cumulative number of cluster-level checks that the vSphere Problem Detector Operator performed. This count includes both successes and failures.
vsphere_cluster_check_errors	Number of failed cluster-level checks that the vSphere Problem Detector Operator performed. For example, a value of **1** indicates that one cluster-level check failed.
vsphere_esxi_version_total	Number of ESXi hosts with a specific version. Be aware that if a host runs more than one node, the host is counted only once.
vsphere_node_check_total	Cumulative number of node-level checks that the vSphere Problem Detector Operator performed. This count includes both successes and failures.
vsphere_node_check_errors	Number of failed node-level checks that the vSphere Problem Detector Operator performed. For example, a value of **1** indicates that one node-level check failed.
vsphere_node_hw_version_total	Number of vSphere nodes with a specific hardware version.
vsphere_vcenter_info	Information about the vSphere vCenter Server.

21.10.8. Additional resources

- Monitoring overview

CHAPTER 22. INSTALLING ON VMC

22.1. PREPARING TO INSTALL ON VMC

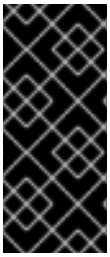
22.1.1. Prerequisites

- You reviewed details about the OpenShift Container Platform installation and update processes.
- You read the documentation on selecting a cluster installation method and preparing it for users.
- If you use a firewall and plan to use Telemetry, you configured the firewall to allow the sites required by your cluster.

22.1.2. Choosing a method to install OpenShift Container Platform on VMC

You can install OpenShift Container Platform on VMC by using installer-provisioned or user-provisioned infrastructure. The default installation type uses installer-provisioned infrastructure, where the installation program provisions the underlying infrastructure for the cluster. You can also install OpenShift Container Platform on infrastructure that you provide. If you do not use infrastructure that the installation program provisions, you must manage and maintain the cluster resources yourself.

See the Installation process for more information about installer-provisioned and user-provisioned installation processes.



IMPORTANT

The steps for performing a user-provisioned infrastructure installation are provided as an example only. Installing a cluster with infrastructure you provide requires knowledge of the VMC platform and the installation process of OpenShift Container Platform. Use the user-provisioned infrastructure installation instructions as a guide; you are free to create the required resources through other methods.

22.1.2.1. Installer-provisioned infrastructure installation of OpenShift Container Platform on VMC

Installer-provisioned infrastructure allows the installation program to pre-configure and automate the provisioning of resources required by OpenShift Container Platform.

- **Installing a cluster on VMC**: You can install OpenShift Container Platform on VMC by using installer-provisioned infrastructure installation with no customization.
- **Installing a cluster on VMC with customizations**: You can install OpenShift Container Platform on VMC by using installer-provisioned infrastructure installation with the default customization options.
- **Installing a cluster on VMC with network customizations**: You can install OpenShift Container Platform on installer-provisioned VMC infrastructure, with network customizations. You can customize your OpenShift Container Platform network configuration during installation, so that your cluster can coexist with your existing IP address allocations and adhere to your network requirements.
- **Installing a cluster on VMC in a restricted network**: You can install a cluster on VMC

infrastructure in a restricted network by creating an internal mirror of the installation release content. You can use this method to deploy OpenShift Container Platform on an internal network that is not visible to the internet.

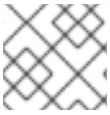
22.1.2.2. User-provisioned infrastructure installation of OpenShift Container Platform on VMC

User-provisioned infrastructure requires the user to provision all resources required by OpenShift Container Platform.

- **Installing a cluster on VMC with user-provisioned infrastructure** You can install OpenShift Container Platform on VMC infrastructure that you provision.
- **Installing a cluster on VMC with user-provisioned infrastructure and network customizations**: You can install OpenShift Container Platform on VMC infrastructure that you provision with customized network configuration options.
- **Installing a cluster on VMC in a restricted network with user-provisioned infrastructure** OpenShift Container Platform can be installed on VMC infrastructure that you provision in a restricted network.

22.1.3. VMware vSphere infrastructure requirements

You must install the OpenShift Container Platform cluster on a VMware vSphere version 7 instance that meets the requirements for the components that you use.



NOTE

OpenShift Container Platform version 4.11 does not support VMware vSphere version 8.0.

You can host the VMware vSphere infrastructure on-premise or on a VMware Cloud Verified provider that meets the requirements outlined in the following table:

Table 22.1. Version requirements for vSphere virtual environments

Virtual environment product	Required version
VM hardware version	15 or later
vSphere ESXi hosts	7
vCenter host	7

IMPORTANT

Installing a cluster on VMware vSphere version 7.0 Update 1 or earlier is now deprecated. These versions are still fully supported, but version 4.11 of OpenShift Container Platform requires vSphere virtual hardware version 15 or later. Hardware version 15 is now the default for vSphere virtual machines in OpenShift Container Platform. To update the hardware version for your vSphere nodes, see the "Updating hardware on nodes running in vSphere" article.

If your vSphere nodes are below hardware version 15 or your VMware vSphere version is earlier than 6.7.3, upgrading from OpenShift Container Platform 4.10 to OpenShift Container Platform 4.11 is not available.

Table 22.2. Minimum supported vSphere version for VMware components

Component	Minimum supported versions	Description
Hypervisor	vSphere 7 with HW version 15	This version is the minimum version that Red Hat Enterprise Linux CoreOS (RHCOS) supports. For more information about supported hardware on the latest version of Red Hat Enterprise Linux (RHEL) that is compatible with RHCOS, see Hardware on the Red Hat Customer Portal.
Storage with in-tree drivers	vSphere 7	This plugin creates vSphere storage by using the in-tree storage drivers for vSphere included in OpenShift Container Platform.

IMPORTANT

You must ensure that the time on your ESXi hosts is synchronized before you install OpenShift Container Platform. See Edit Time Configuration for a Host in the VMware documentation.

22.1.4. VMware vSphere CSI Driver Operator requirements

To install the vSphere CSI Driver Operator, the following requirements must be met:

- VMware vSphere version 7.0 Update 1 or later
- Virtual machines of hardware version 15 or later
- No third-party vSphere CSI driver already installed in the cluster

IMPORTANT

If a third-party vSphere CSI driver is present in the cluster, OpenShift Container Platform does not overwrite it. If you continue with the third-party vSphere CSI driver when upgrading to the next major version of OpenShift Container Platform, the **oc** CLI prompts you with the following message:

```
VSphereCSIDriverOperatorCRUpgradeable: VMwareVSphereControllerUpgradeable:
found existing unsupported csi.vsphere.vmware.com driver
```

The previous message informs you that Red Hat does not support the third-party vSphere CSI driver during an OpenShift Container Platform upgrade operation. You can choose to ignore this message and continue with the upgrade operation.

Additional resources

- To remove a third-party CSI driver, see Removing a third-party vSphere CSI Driver .

22.1.5. Uninstalling an installer-provisioned infrastructure installation of OpenShift Container Platform on VMC

- **Uninstalling a cluster on VMC that uses installer-provisioned infrastructure** You can remove a cluster that you deployed on VMC infrastructure that used installer-provisioned infrastructure.

22.2. INSTALLING A CLUSTER ON VMC

In OpenShift Container Platform version 4.11, you can install a cluster on VMware vSphere by deploying it to VMware Cloud (VMC) on AWS.

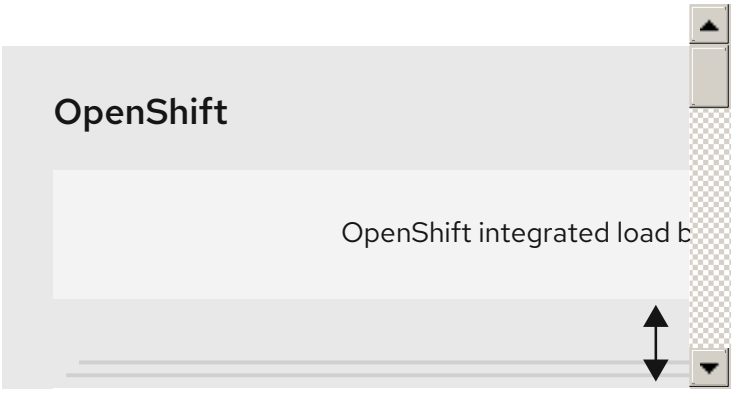
Once you have configured your VMC environment for OpenShift Container Platform deployment, you use the OpenShift Container Platform installation program from the bastion management host, co-located in the VMC environment. The installation program and control plane automates the process of deploying and managing the resources needed for the OpenShift Container Platform cluster.

NOTE

OpenShift Container Platform supports deploying a cluster to a single VMware vCenter only. Deploying a cluster with machines/machine sets on multiple vCenters is not supported.

22.2.1. Setting up VMC for vSphere

You can install OpenShift Container Platform on VMware Cloud (VMC) on AWS hosted vSphere clusters to enable applications to be deployed and managed both on-premise and off-premise, across the hybrid cloud.



You must configure several options in your VMC environment prior to installing OpenShift Container Platform on VMware vSphere. Ensure your VMC environment has the following prerequisites:

- Create a non-exclusive, DHCP-enabled, NSX-T network segment and subnet. Other virtual machines (VMs) can be hosted on the subnet, but at least eight IP addresses must be available for the OpenShift Container Platform deployment.
- Allocate two IP addresses, outside the DHCP range, and configure them with reverse DNS records.
    - A DNS record for **api.<cluster_name>.<base_domain>** pointing to the allocated IP address.
    - A DNS record for ***.apps.<cluster_name>.<base_domain>** pointing to the allocated IP address.
- Configure the following firewall rules:
    - An ANY:ANY firewall rule between the OpenShift Container Platform compute network and the internet. This is used by nodes and applications to download container images.
    - An ANY:ANY firewall rule between the installation host and the software-defined data center (SDDC) management network on port 443. This allows you to upload the Red Hat Enterprise Linux CoreOS (RHCOS) OVA during deployment.
    - An HTTPS firewall rule between the OpenShift Container Platform compute network and vCenter. This connection allows OpenShift Container Platform to communicate with vCenter for provisioning and managing nodes, persistent volume claims (PVCs), and other resources.
- You must have the following information to deploy OpenShift Container Platform:
    - The OpenShift Container Platform cluster name, such as **vmc-prod-1**.
    - The base DNS name, such as **companyname.com**.
    - If not using the default, the pod network CIDR and services network CIDR must be identified, which are set by default to **10.128.0.0/14** and **172.30.0.0/16**, respectively. These CIDRs are used for pod-to-pod and pod-to-service communication and are not accessible externally; however, they must not overlap with existing subnets in your organization.
    - The following vCenter information:
        - vCenter hostname, username, and password
        - Datacenter name, such as **SDDC-Datacenter**

- Cluster name, such as **Cluster-1**
- Network name
- Datastore name, such as **WorkloadDatastore**

NOTE

It is recommended to move your vSphere cluster to the VMC **Compute-ResourcePool** resource pool after your cluster installation is finished.

- A Linux-based host deployed to VMC as a bastion.
  - The bastion host can be Red Hat Enterprise Linux (RHEL) or any another Linux-based host; it must have internet connectivity and the ability to upload an OVA to the ESXi hosts.
  - Download and install the OpenShift CLI tools to the bastion host.
    - The **openshift-install** installation program
    - The OpenShift CLI (**oc**) tool

NOTE

You cannot use the VMware NSX Container Plugin for Kubernetes (NCP), and NSX is not used as the OpenShift SDN. The version of NSX currently available with VMC is incompatible with the version of NCP certified with OpenShift Container Platform.

However, the NSX DHCP service is used for virtual machine IP management with the full-stack automated OpenShift Container Platform deployment and with nodes provisioned, either manually or automatically, by the Machine API integration with vSphere. Additionally, NSX firewall rules are created to enable access with the OpenShift Container Platform cluster and between the bastion host and the VMC vSphere hosts.

22.2.1.1. VMC Sizer tool

VMware Cloud on AWS is built on top of AWS bare metal infrastructure; this is the same bare metal infrastructure which runs AWS native services. When a VMware cloud on AWS software-defined data center (SDDC) is deployed, you consume these physical server nodes and run the VMware ESXi hypervisor in a single tenant fashion. This means the physical infrastructure is not accessible to anyone else using VMC. It is important to consider how many physical hosts you will need to host your virtual infrastructure.

To determine this, VMware provides the VMC on AWS Sizer. With this tool, you can define the resources you intend to host on VMC:

- Types of workloads
- Total number of virtual machines
- Specification information such as:
  - Storage requirements
  - vCPUs

- vRAM
- Overcommit ratios

With these details, the sizer tool can generate a report, based on VMware best practices, and recommend your cluster configuration and the number of hosts you will need.

22.2.2. vSphere prerequisites

- You reviewed details about the OpenShift Container Platform installation and update processes.
- You read the documentation on selecting a cluster installation method and preparing it for users.
- You provisioned block registry storage. For more information on persistent storage, see Understanding persistent storage.
- If you use a firewall, you configured it to allow the sites that your cluster requires access to.

NOTE

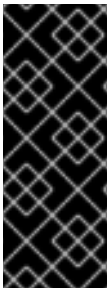
Be sure to also review this site list if you are configuring a proxy.

22.2.3. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.11, you require access to the internet to install your cluster.

You must have internet access to:

- Access OpenShift Cluster Manager Hybrid Cloud Console to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access Quay.io to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.

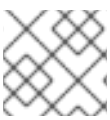


IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

22.2.4. VMware vSphere infrastructure requirements

You must install the OpenShift Container Platform cluster on a VMware vSphere version 7 instance that meets the requirements for the components that you use.



NOTE

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You can host the VMware vSphere infrastructure on-premise or on a VMware Cloud Verified provider that meets the requirements outlined in the following table:

Table 22.3. Version requirements for vSphere virtual environments

Virtual environment product	Required version
VM hardware version	15 or later
vSphere ESXi hosts	7
vCenter host	7

IMPORTANT

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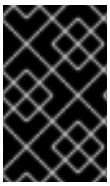
If your vSphere nodes are below hardware version 15 or your VMware vSphere version is earlier than 6.7.3, upgrading from OpenShift Container Platform 4.10 to OpenShift Container Platform 4.11 is not available.

Table 22.4. Minimum supported vSphere version for VMware components

Component	Minimum supported versions	Description
Hypervisor	vSphere 7 with HW version 15	This version is the minimum version that Red Hat Enterprise Linux CoreOS (RHCOS) supports. For more information about supported hardware on the latest version of Red Hat Enterprise Linux (RHEL) that is compatible with RHCOS, see Hardware on the Red Hat Customer Portal.
Storage with in-tree drivers	vSphere 7	This plugin creates vSphere storage by using the in-tree storage drivers for vSphere included in OpenShift Container Platform.



IMPORTANT

You must ensure that the time on your ESXi hosts is synchronized before you install OpenShift Container Platform. See Edit Time Configuration for a Host in the VMware documentation.

22.2.5. Network connectivity requirements

You must configure the network connectivity between machines to allow OpenShift Container Platform cluster components to communicate.

Review the following details about the required network ports.

Table 22.5. Ports used for all-machine to all-machine communications

Protocol	Port	Description
ICMP	N/A	Network reachability tests
TCP	**1936**	Metrics
	9000-**9999**	Host level services, including the node exporter on ports **9100**-**9101** and the Cluster Version Operator on port**9099**.
	10250-**10259**	The default ports that Kubernetes reserves
	10256	openshift-sdn
UDP	**4789**	virtual extensible LAN (VXLAN)
	6081	Geneve
	9000-**9999**	Host level services, including the node exporter on ports **9100**-**9101**.
	500	IPsec IKE packets
	4500	IPsec NAT-T packets
TCP/UDP	**30000**-**32767**	Kubernetes node port
ESP	N/A	IPsec Encapsulating Security Payload (ESP)

Table 22.6. Ports used for all-machine to control plane communications

Protocol	Port	Description
TCP	**6443**	Kubernetes API

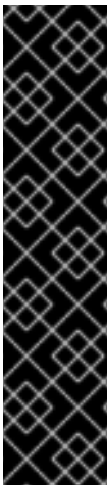
Table 22.7. Ports used for control plane machine to control plane machine communications

Protocol	Port	Description
TCP	**2379-2380**	etcd server and peer ports

22.2.6. VMware vSphere CSI Driver Operator requirements

To install the vSphere CSI Driver Operator, the following requirements must be met:

- VMware vSphere version 7.0 Update 1 or later
- Virtual machines of hardware version 15 or later
- No third-party vSphere CSI driver already installed in the cluster



IMPORTANT

If a third-party vSphere CSI driver is present in the cluster, OpenShift Container Platform does not overwrite it. If you continue with the third-party vSphere CSI driver when upgrading to the next major version of OpenShift Container Platform, the **oc** CLI prompts you with the following message:

> VSphereCSIDriverOperatorCRUpgradeable: VMwareVSphereControllerUpgradeable: found existing unsupported csi.vsphere.vmware.com driver

The previous message informs you that Red Hat does not support the third-party vSphere CSI driver during an OpenShift Container Platform upgrade operation. You can choose to ignore this message and continue with the upgrade operation.

Additional resources

- To remove a third-party CSI driver, see Removing a third-party vSphere CSI Driver .
- To update the hardware version for your vSphere nodes, see Updating hardware on nodes running in vSphere.

22.2.7. vCenter requirements

Before you install an OpenShift Container Platform cluster on your vCenter that uses infrastructure that the installer provisions, you must prepare your environment.

Required vCenter account privileges
To install an OpenShift Container Platform cluster in a vCenter, the installation program requires access to an account with privileges to read and create the required resources. Using an account that has global administrative privileges is the simplest way to access all of the necessary permissions.

If you cannot use an account with global administrative privileges, you must create roles to grant the privileges necessary for OpenShift Container Platform cluster installation. While most of the privileges are always required, some are required only if you plan for the installation program to provision a folder to contain the OpenShift Container Platform cluster on your vCenter instance, which is the default behavior. You must create or amend vSphere roles for the specified objects to grant the required privileges.

An additional role is required if the installation program is to create a vSphere virtual machine folder.

Example 22.1. Roles and privileges required for installation in vSphere API

vSphere object for role	When required	Required privileges in vSphere API
vSphere vCenter	Always	**Cns.Searchable** **InventoryService.Tagging.AttachTag** **InventoryService.Tagging.CreateCategory** **InventoryService.Tagging.CreateTag** **InventoryService.Tagging.DeleteCategory** **InventoryService.Tagging.DeleteTag** **InventoryService.Tagging.EditCategory** **InventoryService.Tagging.EditTag** **Sessions.ValidateSession** **StorageProfile.Update** **StorageProfile.View**
vSphere vCenter Cluster	If VMs will be created in the cluster root	**Host.Config.Storage** **Resource.AssignVMToPool** **VApp.AssignResourcePool** **VApp.Import** **VirtualMachine.Config.AddNewDisk**
vSphere vCenter Resource Pool	If an existing resource pool is provided	**Host.Config.Storage** **Resource.AssignVMToPool** **VApp.AssignResourcePool** **VApp.Import** **VirtualMachine.Config.AddNewDisk**
vSphere Datastore	Always	**Datastore.AllocateSpace** **Datastore.Browse** **Datastore.FileManagement** **InventoryService.Tagging.ObjectAttachable**
vSphere Port Group	Always	**Network.Assign**
Virtual Machine Folder	Always	**InventoryService.Tagging.ObjectAttachable** **Resource.AssignVMToPool** **VApp.Import** **VirtualMachine.Config.Add**

vSphere object for role	When required	Required privileges in vSphere API
		ExistingDisk **VirtualMachine.Config.AddNewDisk** **VirtualMachine.Config.AddRemoveDevice** **VirtualMachine.Config.AdvancedConfig** **VirtualMachine.Config.Annotation** **VirtualMachine.Config.CPUCount** **VirtualMachine.Config.DiskExtend** **VirtualMachine.Config.DiskLease** **VirtualMachine.Config.EditDevice** **VirtualMachine.Config.Memory** **VirtualMachine.Config.RemoveDisk** **VirtualMachine.Config.Rename** **VirtualMachine.Config.ResetGuestInfo** **VirtualMachine.Config.Resource** **VirtualMachine.Config.Settings** **VirtualMachine.Config.UpgradeVirtualHardware** **VirtualMachine.Interact.GuestControl** **VirtualMachine.Interact.PowerOff** **VirtualMachine.Interact.PowerOn** **VirtualMachine.Interact.Reset** **VirtualMachine.Inventory.Create** **VirtualMachine.Inventory.CreateFromExisting** **VirtualMachine.Inventory.Delete** **VirtualMachine.Provisioning.Clone** **VirtualMachine.Provisioning.MarkAsTemplate** **VirtualMachine.Provisioning.DeployTemplate**
vSphere vCenter Datacenter	If the installation program creates the virtual machine folder	**InventoryService.Tagging.ObjectAttachable** **Resource.AssignVMToPool** **VApp.Import**

vSphere object for role	When required	Required privileges in vSphere API
		VirtualMachine.Config.AddExistingDisk VirtualMachine.Config.AddNewDisk VirtualMachine.Config.AddRemoveDevice VirtualMachine.Config.AdvancedConfig VirtualMachine.Config.Annotation VirtualMachine.Config.CPUCount VirtualMachine.Config.DiskExtend VirtualMachine.Config.DiskLease VirtualMachine.Config.EditDevice VirtualMachine.Config.Memory VirtualMachine.Config.RemoveDisk VirtualMachine.Config.Rename VirtualMachine.Config.ResetGuestInfo VirtualMachine.Config.Resource VirtualMachine.Config.Settings VirtualMachine.Config.UpgradeVirtualHardware VirtualMachine.Interact.GuestControl VirtualMachine.Interact.PowerOff VirtualMachine.Interact.PowerOn VirtualMachine.Interact.Reset VirtualMachine.Inventory.Create VirtualMachine.Inventory.CreateFromExisting VirtualMachine.Inventory.Delete VirtualMachine.Provisioning.Clone VirtualMachine.Provisioning.DeployTemplate VirtualMachine.Provisioning.MarkAsTemplate Folder.Create Folder.Delete

Example 22.2. Roles and privileges required for installation in vCenter graphical user interface (GUI)

vSphere object for role	When required	Required privileges in vCenter GUI
vSphere vCenter	Always	**Cns.Searchable "vSphere Tagging"."Assign or Unassign vSphere Tag" "vSphere Tagging"."Create vSphere Tag Category" "vSphere Tagging"."Create vSphere Tag" vSphere Tagging"."Delete vSphere Tag Category" "vSphere Tagging"."Delete vSphere Tag" "vSphere Tagging"."Edit vSphere Tag Category" "vSphere Tagging"."Edit vSphere Tag" Sessions."Validate session" "Profile-driven storage"."Profile-driven storage update" "Profile-driven storage"."Profile-driven storage view"**
vSphere vCenter Cluster	If VMs will be created in the cluster root	**Host.Configuration."Storage partition configuration" Resource."Assign virtual machine to resource pool" VApp."Assign resource pool" VApp.Import "Virtual machine"."Change Configuration"."Add new disk"**
vSphere vCenter Resource Pool	If an existing resource pool is provided	**Host.Configuration."Storage partition configuration" Resource."Assign virtual machine to resource pool" VApp."Assign resource pool" VApp.Import "Virtual machine"."Change Configuration"."Add new disk"**

vSphere object for role	When required	Required privileges in vCenter GUI
vSphere Datastore	Always	**Datastore."Allocate space" Datastore."Browse datastore" Datastore."Low level file operations" "vSphere Tagging"."Assign or Unassign vSphere Tag on Object"**
vSphere Port Group	Always	**Network."Assign network"**
Virtual Machine Folder	Always	**"vSphere Tagging"."Assign or Unassign vSphere Tag on Object" Resource."Assign virtual machine to resource pool" VApp.Import "Virtual machine"."Change Configuration"."Add existing disk" "Virtual machine"."Change Configuration"."Add new disk" "Virtual machine"."Change Configuration"."Add or remove device" "Virtual machine"."Change Configuration"."Advanced configuration" "Virtual machine"."Change Configuration"."Set annotation" "Virtual machine"."Change Configuration"."Change CPU count" "Virtual machine"."Change Configuration"."Extend virtual disk" "Virtual machine"."Change Configuration"."Acquire disk lease" "Virtual machine"."Change Configuration"."Modify device settings" "Virtual machine"."Change Configuration"."Change Memory" "Virtual machine"."Change Configuration"."Remove**

vSphere object for role	When required	Required privileges in vCenter GUI
		disk" "Virtual machine"."Change Configuration".Rename "Virtual machine"."Change Configuration"."Reset guest information" "Virtual machine"."Change Configuration"."Change resource" "Virtual machine"."Change Configuration"."Change Settings" "Virtual machine"."Change Configuration"."Upgrade virtual machine compatibility" "Virtual machine".Interaction."Guest operating system management by VIX API" "Virtual machine".Interaction."Power off" "Virtual machine".Interaction."Power on" "Virtual machine".Interaction.Reset "Virtual machine"."Edit Inventory"."Create new" "Virtual machine"."Edit Inventory"."Create from existing" "Virtual machine"."Edit Inventory"."Remove" "Virtual machine".Provisioning."Clone virtual machine" "Virtual machine".Provisioning."Mark as template" "Virtual machine".Provisioning."Deploy template"
vSphere vCenter Datacenter	If the installation program creates the virtual machine folder	**"vSphere Tagging"."Assign or Unassign vSphere Tag on Object" Resource."Assign virtual machine to resource pool" VApp.Import "Virtual machine"."Change Configuration"."Add existing disk" "Virtual machine"."Change Configuration"."Add new**

vSphere object for role	When required	Required privileges in vCenter GUI
		disk" "Virtual machine"."Change Configuration"."Add or remove device" "Virtual machine"."Change Configuration"."Advanced configuration" "Virtual machine"."Change Configuration"."Set annotation" "Virtual machine"."Change Configuration"."Change CPU count" "Virtual machine"."Change Configuration"."Extend virtual disk" "Virtual machine"."Change Configuration"."Acquire disk lease" "Virtual machine"."Change Configuration"."Modify device settings" "Virtual machine"."Change Configuration"."Change Memory" "Virtual machine"."Change Configuration"."Remove disk" "Virtual machine"."Change Configuration".Rename "Virtual machine"."Change Configuration"."Reset guest information" "Virtual machine"."Change Configuration"."Change resource" "Virtual machine"."Change Configuration"."Change Settings" "Virtual machine"."Change Configuration"."Upgrade virtual machine compatibility" "Virtual machine".Interaction."Guest operating system management by VIX API" "Virtual machine".Interaction."Power off" "Virtual machine".Interaction."Power on" "Virtual machine".Interaction.Reset "Virtual machine"."Edit

vSphere object for role	When required	Required privileges in vCenter GUI
		Inventory"."Create new" "Virtual machine"."Edit Inventory"."Create from existing" "Virtual machine"."Edit Inventory"."Remove" "Virtual machine".Provisioning."Clone virtual machine" "Virtual machine".Provisioning."Deploy template" "Virtual machine".Provisioning."Mark as template" Folder."Create folder" Folder."Delete folder"

Additionally, the user requires some **ReadOnly** permissions, and some of the roles require permission to propogate the permissions to child objects. These settings vary depending on whether or not you install the cluster into an existing folder.

Example 22.3. Required permissions and propagation settings

vSphere object	When required	Propagate to children	Permissions required
vSphere vCenter	Always	False	Listed required privileges
vSphere vCenter Datacenter	Existing folder	False	**ReadOnly** permission
	Installation program creates the folder	True	Listed required privileges
vSphere vCenter Cluster	Existing resource pool	False	**ReadOnly** permission
	VMs in cluster root	True	Listed required privileges
vSphere vCenter Datastore	Always	False	Listed required privileges
vSphere Switch	Always	False	**ReadOnly** permission
vSphere Port Group	Always	False	Listed required privileges
vSphere vCenter Virtual Machine Folder	Existing folder	True	Listed required privileges

vSphere object	When required	Propagate to children	Permissions required
vSphere vCenter Resource Pool	Existing resource pool	True	Listed required privileges

For more information about creating an account with only the required privileges, see vSphere Permissions and User Management Tasks in the vSphere documentation.

Using OpenShift Container Platform with vMotion
If you intend on using vMotion in your vSphere environment, consider the following before installing a OpenShift Container Platform cluster.

- OpenShift Container Platform generally supports compute-only vMotion, where *generally* implies that you meet all VMware best practices for vMotion.
  To help ensure the uptime of your compute and control plane nodes, ensure that you follow the VMware best practices for vMotion, and use VMware anti-affinity rules to improve the availability of OpenShift Container Platform during maintenance or hardware issues.

  For more information about vMotion and anti-affinity rules, see the VMware vSphere documentation for vMotion networking requirements and VM anti-affinity rules.

- Using Storage vMotion can cause issues and is not supported. If you are using vSphere volumes in your pods, migrating a VM across datastores, either manually or through Storage vMotion, causes invalid references within OpenShift Container Platform persistent volume (PV) objects that can result in data loss.

- OpenShift Container Platform does not support selective migration of VMDKs across datastores, using datastore clusters for VM provisioning or for dynamic or static provisioning of PVs, or using a datastore that is part of a datastore cluster for dynamic or static provisioning of PVs.

Cluster resources
When you deploy an OpenShift Container Platform cluster that uses installer-provisioned infrastructure, the installation program must be able to create several resources in your vCenter instance.

A standard OpenShift Container Platform installation creates the following vCenter resources:

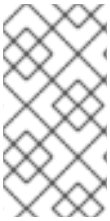
- 1 Folder
- 1 Tag category
- 1 Tag
- Virtual machines:
  - 1 template
  - 1 temporary bootstrap node
  - 3 control plane nodes
  - 3 compute machines

Although these resources use 856 GB of storage, the bootstrap node is destroyed during the cluster installation process. A minimum of 800 GB of storage is required to use a standard cluster.

If you deploy more compute machines, the OpenShift Container Platform cluster will use more storage.

Cluster limits
Available resources vary between clusters. The number of possible clusters within a vCenter is limited primarily by available storage space and any limitations on the number of required resources. Be sure to consider both limitations to the vCenter resources that the cluster creates and the resources that you require to deploy a cluster, such as IP addresses and networks.

Networking requirements
You must use the Dynamic Host Configuration Protocol (DHCP) for the network and ensure that the DHCP server is configured to provide persistent IP addresses to the cluster machines. In the DHCP lease, you must configure the DHCP to use the default gateway. All nodes must be in the same VLAN. You cannot scale the cluster using a second VLAN as a Day 2 operation. Additionally, you must create the following networking resources before you install the OpenShift Container Platform cluster:



NOTE

It is recommended that each OpenShift Container Platform node in the cluster must have access to a Network Time Protocol (NTP) server that is discoverable via DHCP. Installation is possible without an NTP server. However, asynchronous server clocks will cause errors, which NTP server prevents.

Required IP Addresses
An installer-provisioned vSphere installation requires two static IP addresses:

- The **API** address is used to access the cluster API.
- The **Ingress** address is used for cluster ingress traffic.

You must provide these IP addresses to the installation program when you install the OpenShift Container Platform cluster.

DNS records
You must create DNS records for two static IP addresses in the appropriate DNS server for the vCenter instance that hosts your OpenShift Container Platform cluster. In each record, **<cluster_name>** is the cluster name and **<base_domain>** is the cluster base domain that you specify when you install the cluster. A complete DNS record takes the form: **<component>.<cluster_name>.<base_domain>.**.

Table 22.8. Required DNS records

Component	Record	Description
API VIP	**api.<cluster_name>.<base_domain>.**	This DNS A/AAAA or CNAME record must point to the load balancer for the control plane machines. This record must be resolvable by both clients external to the cluster and from all the nodes within the cluster.

Component	Record	Description
Ingress VIP	***.apps.<cluster_name>.<base_domain>.**	A wildcard DNS A/AAAA or CNAME record that points to the load balancer that targets the machines that run the Ingress router pods, which are the worker nodes by default. This record must be resolvable by both clients external to the cluster and from all the nodes within the cluster.

22.2.8. Generating a key pair for cluster node SSH access

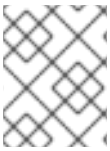
During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the **~/.ssh/authorized_keys** list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The **./openshift-install gather** command also requires the SSH public key to be in place on the cluster nodes.

IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.



NOTE

You must use a local key, not one that you configured with platform-specific approaches such as AWS key pairs.

Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N '' -f <path>/<file_name> 1
```

1. Specify the path and file name, such as **~/.ssh/id_ed25519**, of the new SSH key. If you have an existing key pair, ensure your public key is in the your **~/.ssh** directory.

NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS validated or Modules In Process cryptographic libraries on the **x86_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the ~/**.ssh/id_ed25519.pub** public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the **./openshift-install gather** command.

NOTE

On some distributions, default SSH private key identities such as ~/**.ssh/id_rsa** and ~/**.ssh/id_dsa** are managed automatically.

a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

Example output

```
Agent pid 31874
```

NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

1 Specify the path and file name for your SSH private key, such as ~/**.ssh/id_ed25519**

Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

Next steps

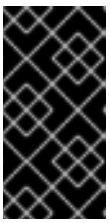
- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

22.2.9. Obtaining the installation program

Before you install OpenShift Container Platform, download the installation file on a local computer.

Prerequisites

- You have a machine that runs Linux, for example Red Hat Enterprise Linux 8, with 500 MB of local disk space.

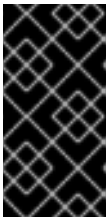


IMPORTANT

If you attempt to run the installation program on macOS, a known issue related to the **golang** compiler causes the installation of the OpenShift Container Platform cluster to fail. For more information about this issue, see the section named "Known Issues" in the *OpenShift Container Platform 4.11 release notes* document.

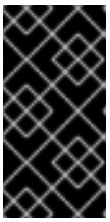
Procedure

1. Access the Infrastructure Provider page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program that corresponds with your host operating system and architecture, and place the file in the directory where you will store the installation configuration files.



IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.



IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation pull secret from the Red Hat OpenShift Cluster Manager . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

22.2.10. Adding vCenter root CA certificates to your system trust

Because the installation program requires access to your vCenter's API, you must add your vCenter's trusted root CA certificates to your system trust before you install an OpenShift Container Platform cluster.

Procedure

1. From the vCenter home page, download the vCenter's root CA certificates. Click **Download trusted root CA certificates** in the vSphere Web Services SDK section. The **<vCenter>/certs/download.zip** file downloads.

2. Extract the compressed file that contains the vCenter root CA certificates. The contents of the compressed file resemble the following file structure:

```
certs
├── lin
│   ├── 108f4d17.0
│   ├── 108f4d17.r1
│   ├── 7e757f6a.0
│   ├── 8e4f8471.0
│   └── 8e4f8471.r0
├── mac
│   ├── 108f4d17.0
│   ├── 108f4d17.r1
│   ├── 7e757f6a.0
│   ├── 8e4f8471.0
│   └── 8e4f8471.r0
└── win
    ├── 108f4d17.0.crt
    ├── 108f4d17.r1.crl
    ├── 7e757f6a.0.crt
    ├── 8e4f8471.0.crt
    └── 8e4f8471.r0.crl

3 directories, 15 files
```

3. Add the files for your operating system to the system trust. For example, on a Fedora operating system, run the following command:

```
# cp certs/lin/* /etc/pki/ca-trust/source/anchors
```

4. Update your system trust. For example, on a Fedora operating system, run the following command:

```
# update-ca-trust extract
```

22.2.11. Deploying the cluster

You can install OpenShift Container Platform on a compatible cloud platform.

IMPORTANT

You can run the **create cluster** command of the installation program only once, during initial installation.

Prerequisites

- Configure an account with the cloud platform that hosts your cluster.
- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.

Procedure

1. Change to the directory that contains the installation program and initialize the cluster deployment:

```
$ ./openshift-install create cluster --dir <installation_directory> \ 1
    --log-level=info 2
```

1 For **<installation_directory>**, specify the directory name to store the files that the installation program creates.

2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

When specifying the directory:

- Verify that the directory has the **execute** permission. This permission is required to run Terraform binaries under the installation directory.
- Use an empty directory. Some installation assets, such as bootstrap X.509 certificates, have short expiration intervals, therefore you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

2. Provide values at the prompts:

   a. Optional: Select an SSH key to use to access your cluster machines.

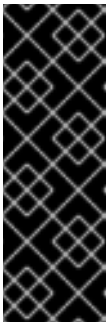
NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

   b. Select **vsphere** as the platform to target.

   c. Specify the name of your vCenter instance.

   d. Specify the user name and password for the vCenter account that has the required permissions to create the cluster.
   The installation program connects to your vCenter instance.



IMPORTANT

Some VMware vCenter Single Sign-On (SSO) environments with Active Directory (AD) integration might primarily require you to use the traditional login method, which requires the **<domain>**\ construct.

To ensure that vCenter account permission checks complete properly, consider using the User Principal Name (UPN) login method, such as **<username>@<fully_qualified_domainname>**.

e. Select the data center in your vCenter instance to connect to.

f. Select the datacenter in your vCenter instance to connect to.

g. Select the default vCenter datastore to use.

NOTE

Datastore and cluster names cannot exceed 60 characters; therefore, ensure the combined string length does not exceed the 60 character limit.

h. Select the vCenter cluster to install the OpenShift Container Platform cluster in. The installation program uses the root resource pool of the vSphere cluster as the default resource pool.

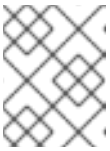
i. Select the network in the vCenter instance that contains the virtual IP addresses and DNS records that you configured.

j. Enter the virtual IP address that you configured for control plane API access.

k. Enter the virtual IP address that you configured for cluster ingress.

l. Enter the base domain. This base domain must be the same one that you used in the DNS records that you configured.

m. Enter a descriptive name for your cluster. The cluster name must be the same one that you used in the DNS records that you configured.



NOTE

Datastore and cluster names cannot exceed 60 characters; therefore, ensure the combined string length does not exceed the 60 character limit.

n. Paste the pull secret from the Red Hat OpenShift Cluster Manager .

IMPORTANT

Use the **openshift-install** command from the bastion hosted in the VMC environment.

+

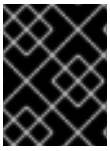
NOTE

If the cloud provider account that you configured on your host does not have sufficient permissions to deploy the cluster, the installation process stops, and the missing permissions are displayed.

Verification

When the cluster deployment completes successfully:

- The terminal displays directions for accessing your cluster, including a link to the web console and credentials for the **kubeadmin** user.
- Credential information also outputs to **<installation_directory>/.openshift_install.log**.

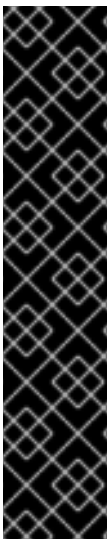


IMPORTANT

Do not delete the installation program or the files that the installation program creates. Both are required to delete the cluster.

Example output

```
...
INFO Install complete!
INFO To access the cluster as the system:admin user when using 'oc', run 'export
KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
INFO Access the OpenShift web-console here: https://console-openshift-
console.apps.mycluster.example.com
INFO Login to the console with user: "kubeadmin", and password: "password"
INFO Time elapsed: 36m22s
```



IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

22.2.12. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.

IMPORTANT

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.11. Download and install the new version of **oc**.

Installing the OpenShift CLI on Linux

You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the architecture in the **Product Variant** drop-down menu.
3. Select the appropriate version in the **Version** drop-down menu.
4. Click **Download Now** next to the **OpenShift v4.11 Linux Client** entry and save the file.
5. Unpack the archive:

```
$ tar xvf <file>
```

6. Place the **oc** binary in a directory that is on your **PATH**.
   To check your **PATH**, execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.
   To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

Verification

Verification

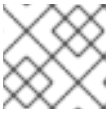
- After you install the OpenShift CLI, it is available using the **oc** command:

```
C:\> oc <command>
```

Installing the OpenShift CLI on macOS
You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 macOS Client** entry and save the file.



NOTE

For macOS arm64, choose the **OpenShift v4.11 macOS arm64 Client** entry.

4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your PATH.
To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

22.2.13. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

Example output

```
system:admin
```

22.2.14. Creating registry storage

After you install the cluster, you must create storage for the registry Operator.

22.2.14.1. Image registry removed during installation

On platforms that do not provide shareable object storage, the OpenShift Image Registry Operator bootstraps itself as **Removed**. This allows **openshift-installer** to complete installations on these platform types.

After installation, you must edit the Image Registry Operator configuration to switch the **managementState** from **Removed** to **Managed**.

22.2.14.2. Image registry storage configuration

The Image Registry Operator is not initially available for platforms that do not provide default storage. After installation, you must configure your registry to use storage so that the Registry Operator is made available.

Instructions are shown for configuring a persistent volume, which is required for production clusters. Where applicable, instructions are shown for configuring an empty directory as the storage location, which is available for only non-production clusters.

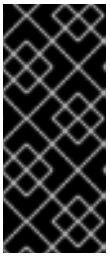
Additional instructions are provided for allowing the image registry to use block storage types by using the **Recreate** rollout strategy during upgrades.

22.2.14.2.1. Configuring registry storage for VMware vSphere

As a cluster administrator, following installation you must configure your registry to use storage.

Prerequisites

- Cluster administrator permissions.
- A cluster on VMware vSphere.
- Persistent storage provisioned for your cluster, such as Red Hat OpenShift Data Foundation.



IMPORTANT

OpenShift Container Platform supports **ReadWriteOnce** access for image registry storage when you have only one replica. **ReadWriteOnce** access also requires that the registry uses the **Recreate** rollout strategy. To deploy an image registry that supports high availability with two or more replicas, **ReadWriteMany** access is required.

- Must have "100Gi" capacity.

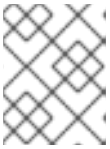
IMPORTANT

Testing shows issues with using the NFS server on RHEL as storage backend for core services. This includes the OpenShift Container Registry and Quay, Prometheus for monitoring storage, and Elasticsearch for logging storage. Therefore, using RHEL NFS to back PVs used by core services is not recommended.

Other NFS implementations on the marketplace might not have these issues. Contact the individual NFS implementation vendor for more information on any testing that was possibly completed against these OpenShift Container Platform core components.

Procedure

1. To configure your registry to use storage, change the **spec.storage.pvc** in the **configs.imageregistry/cluster** resource.



NOTE

When you use shared storage, review your security settings to prevent outside access.

2. Verify that you do not have a registry pod:

```
$ oc get pod -n openshift-image-registry -l docker-registry=default
```

Example output

```
No resourses found in openshift-image-registry namespace
```

NOTE

If you do have a registry pod in your output, you do not need to continue with this procedure.

3. Check the registry configuration:

```
$ oc edit configs.imageregistry.operator.openshift.io
```

Example output

```
storage:
  pvc:
    claim: 1
```

1 Leave the **claim** field blank to allow the automatic creation of an **image-registry-storage** persistent volume claim (PVC). The PVC is generated based on the default storage class. However, be aware that the default storage class might provide ReadWriteOnce (RWO) volumes, such as a RADOS Block Device (RBD), which can cause issues when you replicate to more than one replica.

4. Check the **clusteroperator** status:

```
$ oc get clusteroperator image-registry
```

Example output

```
NAME              VERSION                             AVAILABLE   PROGRESSING   DEGRADED
SINCE   MESSAGE
image-registry    4.7                                 True        False         False      6h50m
```

22.2.14.2.2. Configuring block registry storage for VMware vSphere

To allow the image registry to use block storage types such as vSphere Virtual Machine Disk (VMDK) during upgrades as a cluster administrator, you can use the **Recreate** rollout strategy.

IMPORTANT

Block storage volumes are supported but not recommended for use with image registry on production clusters. An installation where the registry is configured on block storage is not highly available because the registry cannot have more than one replica.

Procedure

1. Enter the following command to set the image registry storage as a block storage type, patch the registry so that it uses the **Recreate** rollout strategy, and runs with only **1** replica:

```
$ oc patch config.imageregistry.operator.openshift.io/cluster --type=merge -p '{"spec":
{"rolloutStrategy":"Recreate","replicas":1}}'
```

2. Provision the PV for the block storage device, and create a PVC for that volume. The requested block volume uses the ReadWriteOnce (RWO) access mode.

   a. Create a **pvc.yaml** file with the following contents to define a VMware vSphere **PersistentVolumeClaim** object:

```
kind: PersistentVolumeClaim
apiVersion: v1
metadata:
  name: image-registry-storage 1
  namespace: openshift-image-registry 2
spec:
  accessModes:
```

```
  - ReadWriteOnce 3
  resources:
    requests:
      storage: 100Gi 4
```

1. A unique name that represents the **PersistentVolumeClaim** object.
2. The namespace for the **PersistentVolumeClaim** object, which is **openshift-image-registry**.
3. The access mode of the persistent volume claim. With **ReadWriteOnce**, the volume can be mounted with read and write permissions by a single node.
4. The size of the persistent volume claim.

b. Enter the following command to create the **PersistentVolumeClaim** object from the file:

```
$ oc create -f pvc.yaml -n openshift-image-registry
```

3. Enter the following command to edit the registry configuration so that it references the correct PVC:

```
$ oc edit config.imageregistry.operator.openshift.io -o yaml
```

Example output

```
storage:
  pvc:
    claim: 1
```

1. By creating a custom PVC, you can leave the **claim** field blank for the default automatic creation of an **image-registry-storage** PVC.

For instructions about configuring registry storage so that it references the correct PVC, see Configuring the registry for vSphere.

22.2.15. Backing up VMware vSphere volumes

OpenShift Container Platform provisions new volumes as independent persistent disks to freely attach and detach the volume on any node in the cluster. As a consequence, it is not possible to back up volumes that use snapshots, or to restore volumes from snapshots. See Snapshot Limitations for more information.

Procedure

To create a backup of persistent volumes:

1. Stop the application that is using the persistent volume.
2. Clone the persistent volume.
3. Restart the application.

4. Create a backup of the cloned volume.
5. Delete the cloned volume.

22.2.16. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.11, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to OpenShift Cluster Manager Hybrid Cloud Console.

After you confirm that your OpenShift Cluster Manager Hybrid Cloud Console inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, use subscription watch to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

Additional resources

- See About remote health monitoring for more information about the Telemetry service

22.2.17. Configuring an external load balancer

You can configure an OpenShift Container Platform cluster to use an external load balancer in place of the default load balancer.

IMPORTANT

Configuring an external load balancer depends on your vendor's load balancer.

The information and examples in this section are for guideline purposes only. Consult the vendor documentation for more specific information about the vendor's load balancer.

Red Hat supports the following services for an external load balancer:

- Ingress Controller
- OpenShift API
- OpenShift MachineConfig API

You can choose whether you want to configure one or all of these services for an external load balancer. Configuring only the Ingress Controller service is a common configuration option. To better understand each service, view the following diagrams:

Figure 22.1. Example network workflow that shows an Ingress Controller operating in an OpenShift Container Platform environment

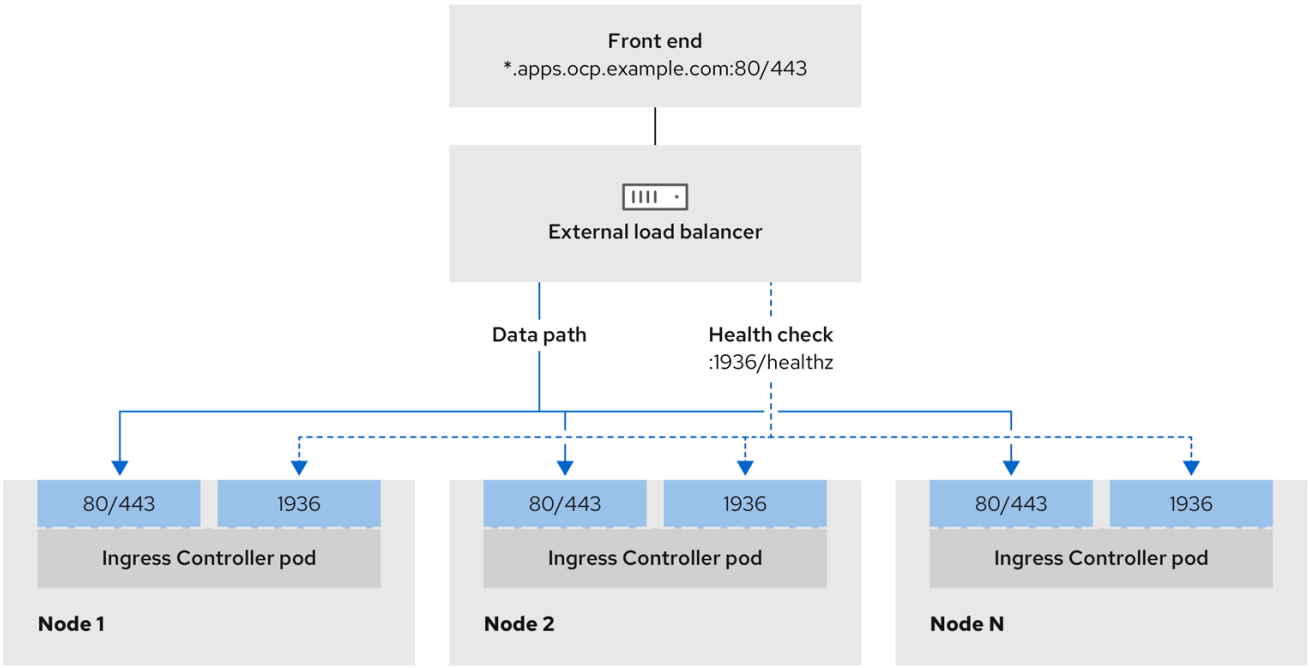


Figure 22.2. Example network workflow that shows an OpenShift API operating in an OpenShift Container Platform environment

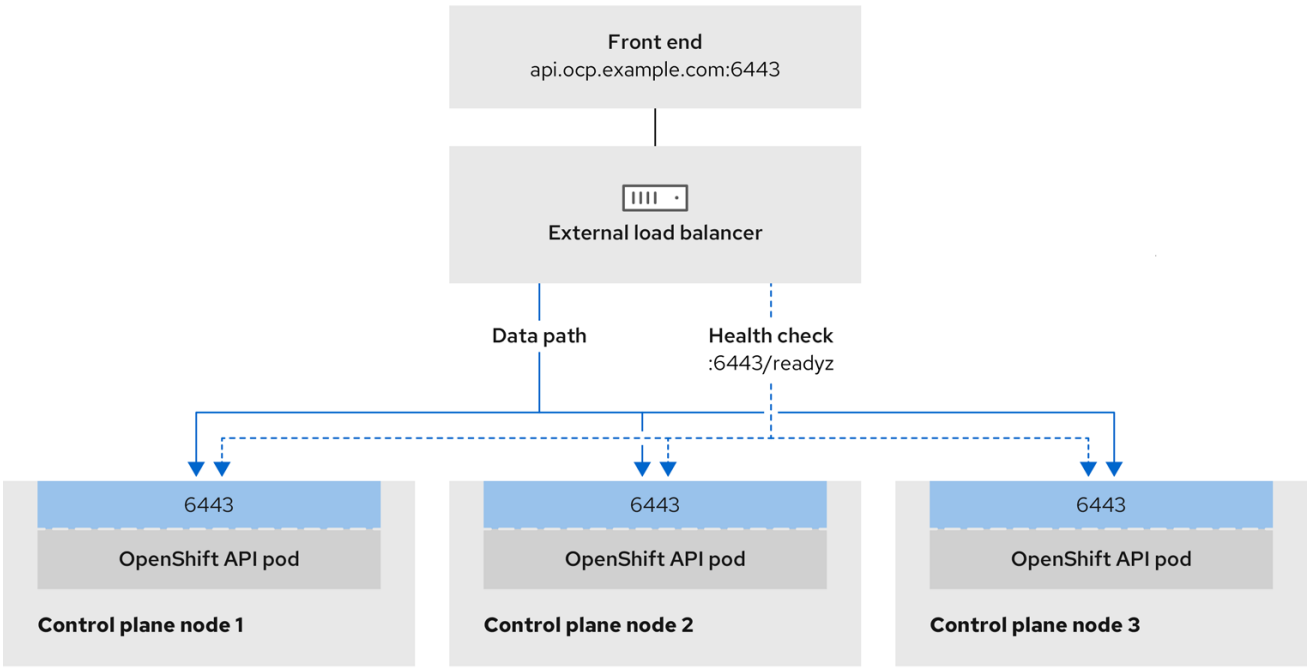
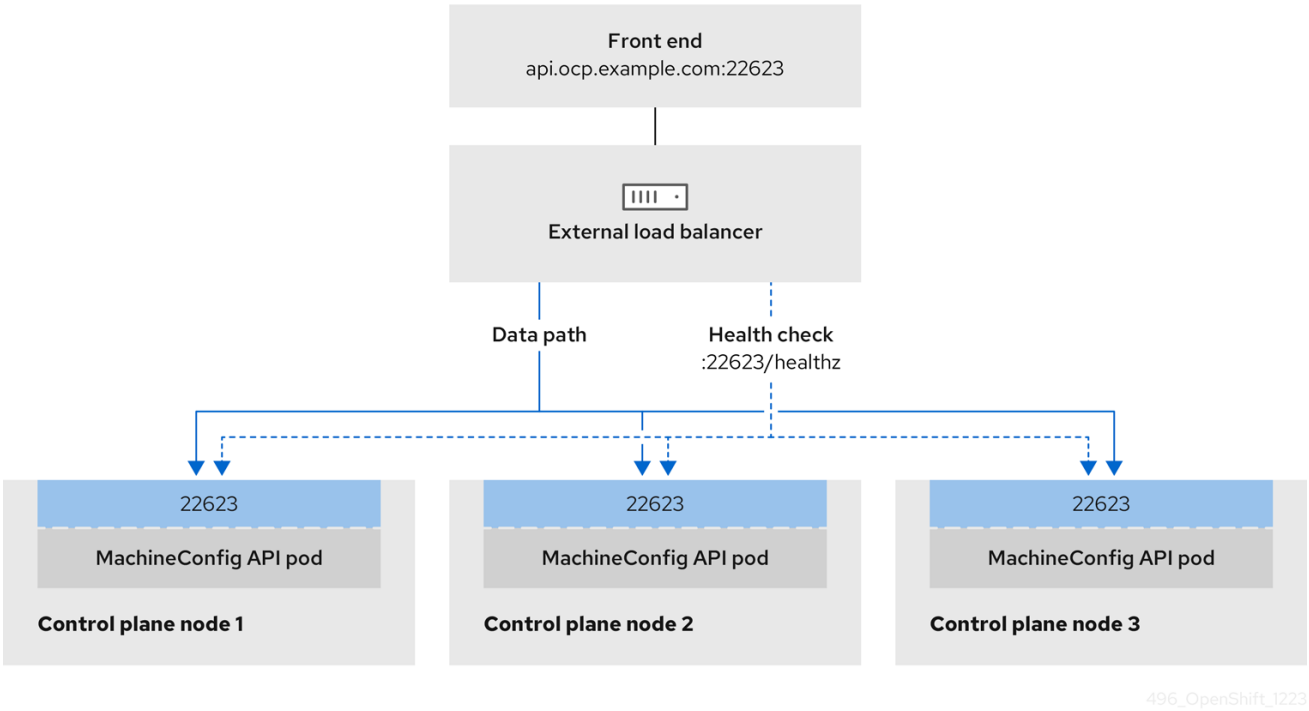


Figure 22.3. Example network workflow that shows an OpenShift MachineConfig API operating in an OpenShift Container Platform environment



Considerations

- For a front-end IP address, you can use the same IP address for the front-end IP address, the Ingress Controller's load balancer, and API load balancer. Check the vendor's documentation for this capability.
- For a back-end IP address, ensure that an IP address for an OpenShift Container Platform control plane node does not change during the lifetime of the external load balancer. You can achieve this by completing one of the following actions:
  - Assign a static IP address to each control plane node.
  - Configure each node to receive the same IP address from the DHCP every time the node requests a DHCP lease. Depending on the vendor, the DHCP lease might be in the form of an IP reservation or a static DHCP assignment.
- Manually define each node that runs the Ingress Controller in the external load balancer for the Ingress Controller back-end service. For example, if the Ingress Controller moves to an undefined node, a connection outage can occur.

OpenShift API prerequisites

- You defined a front-end IP address.
- TCP ports 6443 and 22623 are exposed on the front-end IP address of your load balancer. Check the following items:
  - Port 6443 provides access to the OpenShift API service.
  - Port 22623 can provide ignition startup configurations to nodes.

- The front-end IP address and port 6443 are reachable by all users of your system with a location external to your OpenShift Container Platform cluster.
- The front-end IP address and port 22623 are reachable only by OpenShift Container Platform nodes.
- The load balancer backend can communicate with OpenShift Container Platform control plane nodes on port 6443 and 22623.

Ingress Controller prerequisites

- You defined a front-end IP address.
- TCP ports 443 and 80 are exposed on the front-end IP address of your load balancer.
- The front-end IP address, port 80 and port 443 are be reachable by all users of your system with a location external to your OpenShift Container Platform cluster.
- The front-end IP address, port 80 and port 443 are reachable to all nodes that operate in your OpenShift Container Platform cluster.
- The load balancer backend can communicate with OpenShift Container Platform nodes that run the Ingress Controller on ports 80, 443, and 1936.

Prerequisite for health check URL specifications

You can configure most load balancers by setting health check URLs that determine if a service is available or unavailable. OpenShift Container Platform provides these health checks for the OpenShift API, Machine Configuration API, and Ingress Controller backend services.

The following examples demonstrate health check specifications for the previously listed backend services:

Example of a Kubernetes API health check specification

```
Path: HTTPS:6443/readyz
Healthy threshold: 2
Unhealthy threshold: 2
Timeout: 10
Interval: 10
```

Example of a Machine Config API health check specification

```
Path: HTTPS:22623/healthz
Healthy threshold: 2
Unhealthy threshold: 2
Timeout: 10
Interval: 10
```

Example of an Ingress Controller health check specification

```
Path: HTTP:1936/healthz/ready
Healthy threshold: 2
Unhealthy threshold: 2
```

```
Timeout: 5
Interval: 10
```

Procedure

1. Configure the HAProxy Ingress Controller, so that you can enable access to the cluster from your load balancer on ports 6443, 443, and 80:

   Example HAProxy configuration

```
#...
listen my-cluster-api-6443
    bind 192.168.1.100:6443
    mode tcp
    balance roundrobin
  option httpchk
  http-check connect
  http-check send meth GET uri /readyz
  http-check expect status 200
    server my-cluster-master-2 192.168.1.101:6443 check inter 10s rise 2 fall 2
    server my-cluster-master-0 192.168.1.102:6443 check inter 10s rise 2 fall 2
    server my-cluster-master-1 192.168.1.103:6443 check inter 10s rise 2 fall 2

listen my-cluster-machine-config-api-22623
    bind 192.168.1.1000.0.0.0:22623
    mode tcp
    balance roundrobin
  option httpchk
  http-check connect
  http-check send meth GET uri /healthz
  http-check expect status 200
    server my-cluster-master-2 192.0168.21.2101:22623 check inter 10s rise 2 fall 2
    server my-cluster-master-0 192.168.1.1020.2.3:22623 check inter 10s rise 2 fall 2
    server my-cluster-master-1 192.168.1.1030.2.1:22623 check inter 10s rise 2 fall 2

listen my-cluster-apps-443
        bind 192.168.1.100:443
        mode tcp
        balance roundrobin
    option httpchk
    http-check connect
    http-check send meth GET uri /healthz/ready
    http-check expect status 200
        server my-cluster-worker-0 192.168.1.111:443 check port 1936 inter 10s rise 2 fall 2
        server my-cluster-worker-1 192.168.1.112:443 check port 1936 inter 10s rise 2 fall 2
        server my-cluster-worker-2 192.168.1.113:443 check port 1936 inter 10s rise 2 fall 2

listen my-cluster-apps-80
        bind 192.168.1.100:80
        mode tcp
        balance roundrobin
    option httpchk
    http-check connect
    http-check send meth GET uri /healthz/ready
    http-check expect status 200
```

```
        server my-cluster-worker-0 192.168.1.111:80 check port 1936 inter 10s rise 2 fall 2
        server my-cluster-worker-1 192.168.1.112:80 check port 1936 inter 10s rise 2 fall 2
        server my-cluster-worker-2 192.168.1.113:80 check port 1936 inter 10s rise 2 fall 2
# ...
```

2. Use the **curl** CLI command to verify that the external load balancer and its resources are operational:

   a. Verify that the cluster machine configuration API is accessible to the Kubernetes API server resource, by running the following command and observing the response:

   ```
   $ curl https://<loadbalancer_ip_address>:6443/version --insecure
   ```

   If the configuration is correct, you receive a JSON object in response:

   ```
   {
     "major": "1",
     "minor": "11+",
     "gitVersion": "v1.11.0+ad103ed",
     "gitCommit": "ad103ed",
     "gitTreeState": "clean",
     "buildDate": "2019-01-09T06:44:10Z",
     "goVersion": "go1.10.3",
     "compiler": "gc",
     "platform": "linux/amd64"
   }
   ```

   b. Verify that the cluster machine configuration API is accessible to the Machine config server resource, by running the following command and observing the output:

   ```
   $ curl -v https://<loadbalancer_ip_address>:22623/healthz --insecure
   ```

   If the configuration is correct, the output from the command shows the following response:

   ```
   HTTP/1.1 200 OK
   Content-Length: 0
   ```

   c. Verify that the controller is accessible to the Ingress Controller resource on port 80, by running the following command and observing the output:

   ```
   $ curl -I -L -H "Host: console-openshift-console.apps.<cluster_name>.<base_domain>"
   http://<load_balancer_front_end_IP_address>
   ```

   If the configuration is correct, the output from the command shows the following response:

   ```
   HTTP/1.1 302 Found
   content-length: 0
   location: https://console-openshift-console.apps.ocp4.private.opequon.net/
   cache-control: no-cache
   ```

   d. Verify that the controller is accessible to the Ingress Controller resource on port 443, by running the following command and observing the output:

```
$ curl -I -L --insecure --resolve console-openshift-console.apps.<cluster_name>.
<base_domain>:443:<Load Balancer Front End IP Address> https://console-openshift-
console.apps.<cluster_name>.<base_domain>
```

If the configuration is correct, the output from the command shows the following response:

```
HTTP/1.1 200 OK
referrer-policy: strict-origin-when-cross-origin
set-cookie: csrf-
token=UlYWOyQ62LWjw2h003xtYSKlh1a0Py2hhctw0WmV2YEdhJjFyQwWcGBsja261dG
LgaYO0nxzVErhiXt6QepA7g==; Path=/; Secure; SameSite=Lax
x-content-type-options: nosniff
x-dns-prefetch-control: off
x-frame-options: DENY
x-xss-protection: 1; mode=block
date: Wed, 04 Oct 2023 16:29:38 GMT
content-type: text/html; charset=utf-8
set-cookie:
1e2670d92730b515ce3a1bb65da45062=1bf5e9573c9a2760c964ed1659cc1673; path=/;
HttpOnly; Secure; SameSite=None
cache-control: private
```

3. Configure the DNS records for your cluster to target the front-end IP addresses of the external load balancer. You must update records to your DNS server for the cluster API and applications over the load balancer.

Examples of modified DNS records

```
<load_balancer_ip_address>  A  api.<cluster_name>.<base_domain>
A record pointing to Load Balancer Front End
```

```
<load_balancer_ip_address>  A apps.<cluster_name>.<base_domain>
A record pointing to Load Balancer Front End
```

IMPORTANT

DNS propagation might take some time for each DNS record to become available. Ensure that each DNS record propagates before validating each record.

4. Use the **curl** CLI command to verify that the external load balancer and DNS record configuration are operational:

   a. Verify that you can access the cluster API, by running the following command and observing the output:

```
$ curl https://api.<cluster_name>.<base_domain>:6443/version --insecure
```

   If the configuration is correct, you receive a JSON object in response:

```
{
  "major": "1",
  "minor": "11+",
```

```
  "gitVersion": "v1.11.0+ad103ed",
  "gitCommit": "ad103ed",
  "gitTreeState": "clean",
  "buildDate": "2019-01-09T06:44:10Z",
  "goVersion": "go1.10.3",
  "compiler": "gc",
  "platform": "linux/amd64"
  }
```

b. Verify that you can access the cluster machine configuration, by running the following command and observing the output:

```
$ curl -v https://api.<cluster_name>.<base_domain>:22623/healthz --insecure
```

If the configuration is correct, the output from the command shows the following response:

```
HTTP/1.1 200 OK
Content-Length: 0
```

c. Verify that you can access each cluster application on port, by running the following command and observing the output:

```
$ curl http://console-openshift-console.apps.<cluster_name>.<base_domain> -I -L --
insecure
```

If the configuration is correct, the output from the command shows the following response:

```
HTTP/1.1 302 Found
content-length: 0
location: https://console-openshift-console.apps.<cluster-name>.<base domain>/
cache-control: no-cacheHTTP/1.1 200 OK
referrer-policy: strict-origin-when-cross-origin
set-cookie: csrf-
token=39HoZgztDnzjJkq/JuLJMeoKNXlfiVv2YgZc09c3TBOBU4NI6kDXaJH1LdicNhN1UsQ
Wzon4Dor9GWGfopaTEQ==; Path=/; Secure
x-content-type-options: nosniff
x-dns-prefetch-control: off
x-frame-options: DENY
x-xss-protection: 1; mode=block
date: Tue, 17 Nov 2020 08:42:10 GMT
content-type: text/html; charset=utf-8
set-cookie:
1e2670d92730b515ce3a1bb65da45062=9b714eb87e93cf34853e87a92d6894be; path=/;
HttpOnly; Secure; SameSite=None
cache-control: private
```

d. Verify that you can access each cluster application on port 443, by running the following command and observing the output:

```
$ curl https://console-openshift-console.apps.<cluster_name>.<base_domain> -I -L --
insecure
```

If the configuration is correct, the output from the command shows the following response:

```
HTTP/1.1 200 OK
referrer-policy: strict-origin-when-cross-origin
set-cookie: csrf-
token=UlYWOyQ62LWjw2h003xtYSKlh1a0Py2hhctw0WmV2YEdhJjFyQwWcGBsja261dG
LgaYO0nxzVErhiXt6QepA7g==; Path=/; Secure; SameSite=Lax
x-content-type-options: nosniff
x-dns-prefetch-control: off
x-frame-options: DENY
x-xss-protection: 1; mode=block
date: Wed, 04 Oct 2023 16:29:38 GMT
content-type: text/html; charset=utf-8
set-cookie:
1e2670d92730b515ce3a1bb65da45062=1bf5e9573c9a2760c964ed1659cc1673; path=/;
HttpOnly; Secure; SameSite=None
cache-control: private
```

22.2.18. Next steps

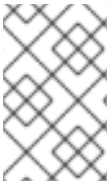
- Customize your cluster.
- If necessary, you can opt out of remote health reporting .
- Set up your registry and configure registry storage .
- Optional: View the events from the vSphere Problem Detector Operator to determine if the cluster has permission or storage configuration issues.

22.3. INSTALLING A CLUSTER ON VMC WITH CUSTOMIZATIONS

In OpenShift Container Platform version 4.11, you can install a cluster on your VMware vSphere instance using installer-provisioned infrastructure by deploying it to VMware Cloud (VMC) on AWS.

Once you configure your VMC environment for OpenShift Container Platform deployment, you use the OpenShift Container Platform installation program from the bastion management host, co-located in the VMC environment. The installation program and control plane automates the process of deploying and managing the resources needed for the OpenShift Container Platform cluster.

To customize the OpenShift Container Platform installation, you modify parameters in the **install-config.yaml** file before you install the cluster.

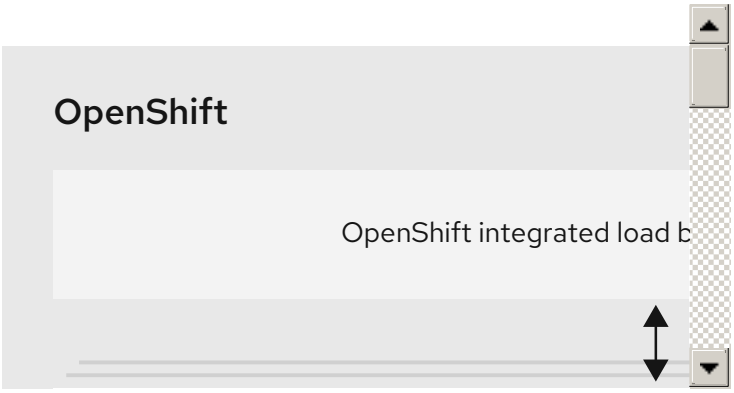


NOTE

OpenShift Container Platform supports deploying a cluster to a single VMware vCenter only. Deploying a cluster with machines/machine sets on multiple vCenters is not supported.

22.3.1. Setting up VMC for vSphere

You can install OpenShift Container Platform on VMware Cloud (VMC) on AWS hosted vSphere clusters to enable applications to be deployed and managed both on-premise and off-premise, across the hybrid cloud.



You must configure several options in your VMC environment prior to installing OpenShift Container Platform on VMware vSphere. Ensure your VMC environment has the following prerequisites:

- Create a non-exclusive, DHCP-enabled, NSX-T network segment and subnet. Other virtual machines (VMs) can be hosted on the subnet, but at least eight IP addresses must be available for the OpenShift Container Platform deployment.
- Allocate two IP addresses, outside the DHCP range, and configure them with reverse DNS records.
    - A DNS record for **api.<cluster_name>.<base_domain>** pointing to the allocated IP address.
    - A DNS record for ***.apps.<cluster_name>.<base_domain>** pointing to the allocated IP address.
- Configure the following firewall rules:
    - An ANY:ANY firewall rule between the OpenShift Container Platform compute network and the internet. This is used by nodes and applications to download container images.
    - An ANY:ANY firewall rule between the installation host and the software-defined data center (SDDC) management network on port 443. This allows you to upload the Red Hat Enterprise Linux CoreOS (RHCOS) OVA during deployment.
    - An HTTPS firewall rule between the OpenShift Container Platform compute network and vCenter. This connection allows OpenShift Container Platform to communicate with vCenter for provisioning and managing nodes, persistent volume claims (PVCs), and other resources.
- You must have the following information to deploy OpenShift Container Platform:
    - The OpenShift Container Platform cluster name, such as **vmc-prod-1**.
    - The base DNS name, such as **companyname.com**.
    - If not using the default, the pod network CIDR and services network CIDR must be identified, which are set by default to **10.128.0.0/14** and **172.30.0.0/16**, respectively. These CIDRs are used for pod-to-pod and pod-to-service communication and are not accessible externally; however, they must not overlap with existing subnets in your organization.
    - The following vCenter information:
        - vCenter hostname, username, and password
        - Datacenter name, such as **SDDC-Datacenter**

- Cluster name, such as **Cluster-1**
- Network name
- Datastore name, such as **WorkloadDatastore**

NOTE

It is recommended to move your vSphere cluster to the VMC **Compute-ResourcePool** resource pool after your cluster installation is finished.

- A Linux-based host deployed to VMC as a bastion.
  - The bastion host can be Red Hat Enterprise Linux (RHEL) or any another Linux-based host; it must have internet connectivity and the ability to upload an OVA to the ESXi hosts.
  - Download and install the OpenShift CLI tools to the bastion host.
    - The **openshift-install** installation program
    - The OpenShift CLI (**oc**) tool

NOTE

You cannot use the VMware NSX Container Plugin for Kubernetes (NCP), and NSX is not used as the OpenShift SDN. The version of NSX currently available with VMC is incompatible with the version of NCP certified with OpenShift Container Platform.

However, the NSX DHCP service is used for virtual machine IP management with the full-stack automated OpenShift Container Platform deployment and with nodes provisioned, either manually or automatically, by the Machine API integration with vSphere. Additionally, NSX firewall rules are created to enable access with the OpenShift Container Platform cluster and between the bastion host and the VMC vSphere hosts.

22.3.1.1. VMC Sizer tool

VMware Cloud on AWS is built on top of AWS bare metal infrastructure; this is the same bare metal infrastructure which runs AWS native services. When a VMware cloud on AWS software-defined data center (SDDC) is deployed, you consume these physical server nodes and run the VMware ESXi hypervisor in a single tenant fashion. This means the physical infrastructure is not accessible to anyone else using VMC. It is important to consider how many physical hosts you will need to host your virtual infrastructure.

To determine this, VMware provides the VMC on AWS Sizer. With this tool, you can define the resources you intend to host on VMC:

- Types of workloads
- Total number of virtual machines
- Specification information such as:
  - Storage requirements
  - vCPUs

- vRAM
- Overcommit ratios

With these details, the sizer tool can generate a report, based on VMware best practices, and recommend your cluster configuration and the number of hosts you will need.

22.3.2. vSphere prerequisites

- You reviewed details about the OpenShift Container Platform installation and update processes.
- You read the documentation on selecting a cluster installation method and preparing it for users.
- You provisioned block registry storage. For more information on persistent storage, see Understanding persistent storage.
- If you use a firewall, you configured it to allow the sites that your cluster requires access to.

NOTE

Be sure to also review this site list if you are configuring a proxy.

22.3.3. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.11, you require access to the internet to install your cluster.

You must have internet access to:

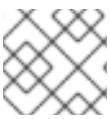
- Access OpenShift Cluster Manager Hybrid Cloud Console to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access Quay.io to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.

IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

22.3.4. VMware vSphere infrastructure requirements

You must install the OpenShift Container Platform cluster on a VMware vSphere version 7 instance that meets the requirements for the components that you use.



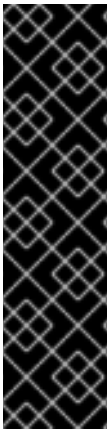
NOTE

OpenShift Container Platform version 4.11 does not support VMware vSphere version 8.0.

You can host the VMware vSphere infrastructure on-premise or on a VMware Cloud Verified provider that meets the requirements outlined in the following table:

Table 22.9. Version requirements for vSphere virtual environments

Virtual environment product	Required version
VM hardware version	15 or later
vSphere ESXi hosts	7
vCenter host	7



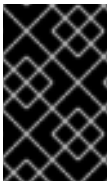
IMPORTANT

Installing a cluster on VMware vSphere version 7.0 Update 1 or earlier is now deprecated. These versions are still fully supported, but version 4.11 of OpenShift Container Platform requires vSphere virtual hardware version 15 or later. Hardware version 15 is now the default for vSphere virtual machines in OpenShift Container Platform. To update the hardware version for your vSphere nodes, see the "Updating hardware on nodes running in vSphere" article.

If your vSphere nodes are below hardware version 15 or your VMware vSphere version is earlier than 6.7.3, upgrading from OpenShift Container Platform 4.10 to OpenShift Container Platform 4.11 is not available.

Table 22.10. Minimum supported vSphere version for VMware components

Component	Minimum supported versions	Description
Hypervisor	vSphere 7 with HW version 15	This version is the minimum version that Red Hat Enterprise Linux CoreOS (RHCOS) supports. For more information about supported hardware on the latest version of Red Hat Enterprise Linux (RHEL) that is compatible with RHCOS, see Hardware on the Red Hat Customer Portal.
Storage with in-tree drivers	vSphere 7	This plugin creates vSphere storage by using the in-tree storage drivers for vSphere included in OpenShift Container Platform.



IMPORTANT

You must ensure that the time on your ESXi hosts is synchronized before you install OpenShift Container Platform. See Edit Time Configuration for a Host in the VMware documentation.

22.3.5. Network connectivity requirements

You must configure the network connectivity between machines to allow OpenShift Container Platform cluster components to communicate.

Review the following details about the required network ports.

Table 22.11. Ports used for all-machine to all-machine communications

Protocol	Port	Description
ICMP	N/A	Network reachability tests
TCP	**1936**	Metrics
	9000-**9999**	Host level services, including the node exporter on ports **9100**-**9101** and the Cluster Version Operator on port**9099**.
	10250-**10259**	The default ports that Kubernetes reserves
	10256	openshift-sdn
UDP	**4789**	virtual extensible LAN (VXLAN)
	6081	Geneve
	9000-**9999**	Host level services, including the node exporter on ports **9100**-**9101**.
	500	IPsec IKE packets
	4500	IPsec NAT-T packets
TCP/UDP	**30000**-**32767**	Kubernetes node port
ESP	N/A	IPsec Encapsulating Security Payload (ESP)

Table 22.12. Ports used for all-machine to control plane communications

Protocol	Port	Description
TCP	**6443**	Kubernetes API

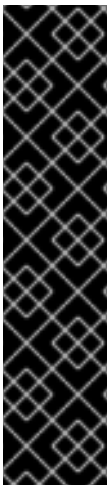
Table 22.13. Ports used for control plane machine to control plane machine communications

Protocol	Port	Description
TCP	**2379-2380**	etcd server and peer ports

22.3.6. VMware vSphere CSI Driver Operator requirements

To install the vSphere CSI Driver Operator, the following requirements must be met:

- VMware vSphere version 7.0 Update 1 or later
- Virtual machines of hardware version 15 or later
- No third-party vSphere CSI driver already installed in the cluster



IMPORTANT

If a third-party vSphere CSI driver is present in the cluster, OpenShift Container Platform does not overwrite it. If you continue with the third-party vSphere CSI driver when upgrading to the next major version of OpenShift Container Platform, the **oc** CLI prompts you with the following message:

> VSphereCSIDriverOperatorCRUpgradeable: VMwareVSphereControllerUpgradeable: found existing unsupported csi.vsphere.vmware.com driver

The previous message informs you that Red Hat does not support the third-party vSphere CSI driver during an OpenShift Container Platform upgrade operation. You can choose to ignore this message and continue with the upgrade operation.

Additional resources

- To remove a third-party CSI driver, see Removing a third-party vSphere CSI Driver .
- To update the hardware version for your vSphere nodes, see Updating hardware on nodes running in vSphere.

22.3.7. vCenter requirements

Before you install an OpenShift Container Platform cluster on your vCenter that uses infrastructure that the installer provisions, you must prepare your environment.

Required vCenter account privileges
To install an OpenShift Container Platform cluster in a vCenter, the installation program requires access to an account with privileges to read and create the required resources. Using an account that has global administrative privileges is the simplest way to access all of the necessary permissions.

If you cannot use an account with global administrative privileges, you must create roles to grant the privileges necessary for OpenShift Container Platform cluster installation. While most of the privileges are always required, some are required only if you plan for the installation program to provision a folder to contain the OpenShift Container Platform cluster on your vCenter instance, which is the default behavior. You must create or amend vSphere roles for the specified objects to grant the required privileges.

An additional role is required if the installation program is to create a vSphere virtual machine folder.

Example 22.4. Roles and privileges required for installation in vSphere API

vSphere object for role	When required	Required privileges in vSphere API
vSphere vCenter	Always	**Cns.Searchable** **InventoryService.Tagging.AttachTag** **InventoryService.Tagging.CreateCategory** **InventoryService.Tagging.CreateTag** **InventoryService.Tagging.DeleteCategory** **InventoryService.Tagging.DeleteTag** **InventoryService.Tagging.EditCategory** **InventoryService.Tagging.EditTag** **Sessions.ValidateSession** **StorageProfile.Update** **StorageProfile.View**
vSphere vCenter Cluster	If VMs will be created in the cluster root	**Host.Config.Storage** **Resource.AssignVMToPool** **VApp.AssignResourcePool** **VApp.Import** **VirtualMachine.Config.AddNewDisk**
vSphere vCenter Resource Pool	If an existing resource pool is provided	**Host.Config.Storage** **Resource.AssignVMToPool** **VApp.AssignResourcePool** **VApp.Import** **VirtualMachine.Config.AddNewDisk**
vSphere Datastore	Always	**Datastore.AllocateSpace** **Datastore.Browse** **Datastore.FileManagement** **InventoryService.Tagging.ObjectAttachable**
vSphere Port Group	Always	**Network.Assign**
Virtual Machine Folder	Always	**InventoryService.Tagging.ObjectAttachable** **Resource.AssignVMToPool** **VApp.Import** **VirtualMachine.Config.Add**

vSphere object for role	When required	Required privileges in vSphere API
		ExistingDisk **VirtualMachine.Config.AddNewDisk** **VirtualMachine.Config.AddRemoveDevice** **VirtualMachine.Config.AdvancedConfig** **VirtualMachine.Config.Annotation** **VirtualMachine.Config.CPUCount** **VirtualMachine.Config.DiskExtend** **VirtualMachine.Config.DiskLease** **VirtualMachine.Config.EditDevice** **VirtualMachine.Config.Memory** **VirtualMachine.Config.RemoveDisk** **VirtualMachine.Config.Rename** **VirtualMachine.Config.ResetGuestInfo** **VirtualMachine.Config.Resource** **VirtualMachine.Config.Settings** **VirtualMachine.Config.UpgradeVirtualHardware** **VirtualMachine.Interact.GuestControl** **VirtualMachine.Interact.PowerOff** **VirtualMachine.Interact.PowerOn** **VirtualMachine.Interact.Reset** **VirtualMachine.Inventory.Create** **VirtualMachine.Inventory.CreateFromExisting** **VirtualMachine.Inventory.Delete** **VirtualMachine.Provisioning.Clone** **VirtualMachine.Provisioning.MarkAsTemplate** **VirtualMachine.Provisioning.DeployTemplate**
vSphere vCenter Datacenter	If the installation program creates the virtual machine folder	**InventoryService.Tagging.ObjectAttachable** **Resource.AssignVMToPool** **VApp.Import**

vSphere object for role	When required	Required privileges in vSphere API
		VirtualMachine.Config.AddExistingDisk VirtualMachine.Config.AddNewDisk VirtualMachine.Config.AddRemoveDevice VirtualMachine.Config.AdvancedConfig VirtualMachine.Config.Annotation VirtualMachine.Config.CPUCount VirtualMachine.Config.DiskExtend VirtualMachine.Config.DiskLease VirtualMachine.Config.EditDevice VirtualMachine.Config.Memory VirtualMachine.Config.RemoveDisk VirtualMachine.Config.Rename VirtualMachine.Config.ResetGuestInfo VirtualMachine.Config.Resource VirtualMachine.Config.Settings VirtualMachine.Config.UpgradeVirtualHardware VirtualMachine.Interact.GuestControl VirtualMachine.Interact.PowerOff VirtualMachine.Interact.PowerOn VirtualMachine.Interact.Reset VirtualMachine.Inventory.Create VirtualMachine.Inventory.CreateFromExisting VirtualMachine.Inventory.Delete VirtualMachine.Provisioning.Clone VirtualMachine.Provisioning.DeployTemplate VirtualMachine.Provisioning.MarkAsTemplate Folder.Create Folder.Delete

Example 22.5. Roles and privileges required for installation in vCenter graphical user interface (GUI)

vSphere object for role	When required	Required privileges in vCenter GUI
vSphere vCenter	Always	**Cns.Searchable "vSphere Tagging"."Assign or Unassign vSphere Tag" "vSphere Tagging"."Create vSphere Tag Category" "vSphere Tagging"."Create vSphere Tag" vSphere Tagging"."Delete vSphere Tag Category" "vSphere Tagging"."Delete vSphere Tag" "vSphere Tagging"."Edit vSphere Tag Category" "vSphere Tagging"."Edit vSphere Tag" Sessions."Validate session" "Profile-driven storage"."Profile-driven storage update" "Profile-driven storage"."Profile-driven storage view"**
vSphere vCenter Cluster	If VMs will be created in the cluster root	**Host.Configuration."Storage partition configuration" Resource."Assign virtual machine to resource pool" VApp."Assign resource pool" VApp.Import "Virtual machine"."Change Configuration"."Add new disk"**
vSphere vCenter Resource Pool	If an existing resource pool is provided	**Host.Configuration."Storage partition configuration" Resource."Assign virtual machine to resource pool" VApp."Assign resource pool" VApp.Import "Virtual machine"."Change Configuration"."Add new disk"**

vSphere object for role	When required	Required privileges in vCenter GUI
vSphere Datastore	Always	**Datastore."Allocate space" Datastore."Browse datastore" Datastore."Low level file operations" "vSphere Tagging"."Assign or Unassign vSphere Tag on Object"**
vSphere Port Group	Always	**Network."Assign network"**
Virtual Machine Folder	Always	**"vSphere Tagging"."Assign or Unassign vSphere Tag on Object" Resource."Assign virtual machine to resource pool" VApp.Import "Virtual machine"."Change Configuration"."Add existing disk" "Virtual machine"."Change Configuration"."Add new disk" "Virtual machine"."Change Configuration"."Add or remove device" "Virtual machine"."Change Configuration"."Advanced configuration" "Virtual machine"."Change Configuration"."Set annotation" "Virtual machine"."Change Configuration"."Change CPU count" "Virtual machine"."Change Configuration"."Extend virtual disk" "Virtual machine"."Change Configuration"."Acquire disk lease" "Virtual machine"."Change Configuration"."Modify device settings" "Virtual machine"."Change Configuration"."Change Memory" "Virtual machine"."Change Configuration"."Remove**

vSphere object for role	When required	Required privileges in vCenter GUI
		disk" **"Virtual machine"."Change Configuration".Rename** **"Virtual machine"."Change Configuration"."Reset guest information"** **"Virtual machine"."Change Configuration"."Change resource"** **"Virtual machine"."Change Configuration"."Change Settings"** **"Virtual machine"."Change Configuration"."Upgrade virtual machine compatibility"** **"Virtual machine".Interaction."Guest operating system management by VIX API"** **"Virtual machine".Interaction."Power off"** **"Virtual machine".Interaction."Power on"** **"Virtual machine".Interaction.Reset** **"Virtual machine"."Edit Inventory"."Create new"** **"Virtual machine"."Edit Inventory"."Create from existing"** **"Virtual machine"."Edit Inventory"."Remove"** **"Virtual machine".Provisioning."Clone virtual machine"** **"Virtual machine".Provisioning."Mark as template"** **"Virtual machine".Provisioning."Deploy template"**
vSphere vCenter Datacenter	If the installation program creates the virtual machine folder	**"vSphere Tagging"."Assign or Unassign vSphere Tag on Object"** **Resource."Assign virtual machine to resource pool"** **VApp.Import** **"Virtual machine"."Change Configuration"."Add existing disk"** **"Virtual machine"."Change Configuration"."Add new**

vSphere object for role	When required	Required privileges in vCenter GUI
		disk" "Virtual machine"."Change Configuration"."Add or remove device" "Virtual machine"."Change Configuration"."Advanced configuration" "Virtual machine"."Change Configuration"."Set annotation" "Virtual machine"."Change Configuration"."Change CPU count" "Virtual machine"."Change Configuration"."Extend virtual disk" "Virtual machine"."Change Configuration"."Acquire disk lease" "Virtual machine"."Change Configuration"."Modify device settings" "Virtual machine"."Change Configuration"."Change Memory" "Virtual machine"."Change Configuration"."Remove disk" "Virtual machine"."Change Configuration".Rename "Virtual machine"."Change Configuration"."Reset guest information" "Virtual machine"."Change Configuration"."Change resource" "Virtual machine"."Change Configuration"."Change Settings" "Virtual machine"."Change Configuration"."Upgrade virtual machine compatibility" "Virtual machine".Interaction."Guest operating system management by VIX API" "Virtual machine".Interaction."Power off" "Virtual machine".Interaction."Power on" "Virtual machine".Interaction.Reset "Virtual machine"."Edit

vSphere object for role	When required	Required privileges in vCenter GUI
		Inventory"."Create new" "Virtual machine"."Edit Inventory"."Create from existing" "Virtual machine"."Edit Inventory"."Remove" "Virtual machine".Provisioning."Clone virtual machine" "Virtual machine".Provisioning."Deploy template" "Virtual machine".Provisioning."Mark as template" Folder."Create folder" Folder."Delete folder"

Additionally, the user requires some **ReadOnly** permissions, and some of the roles require permission to propogate the permissions to child objects. These settings vary depending on whether or not you install the cluster into an existing folder.

Example 22.6. Required permissions and propagation settings

vSphere object	When required	Propagate to children	Permissions required
vSphere vCenter	Always	False	Listed required privileges
vSphere vCenter Datacenter	Existing folder	False	**ReadOnly** permission
	Installation program creates the folder	True	Listed required privileges
vSphere vCenter Cluster	Existing resource pool	False	**ReadOnly** permission
	VMs in cluster root	True	Listed required privileges
vSphere vCenter Datastore	Always	False	Listed required privileges
vSphere Switch	Always	False	**ReadOnly** permission
vSphere Port Group	Always	False	Listed required privileges
vSphere vCenter Virtual Machine Folder	Existing folder	True	Listed required privileges

vSphere object	When required	Propagate to children	Permissions required
vSphere vCenter Resource Pool	Existing resource pool	True	Listed required privileges

For more information about creating an account with only the required privileges, see vSphere Permissions and User Management Tasks in the vSphere documentation.

Using OpenShift Container Platform with vMotion
If you intend on using vMotion in your vSphere environment, consider the following before installing a OpenShift Container Platform cluster.

- OpenShift Container Platform generally supports compute-only vMotion, where *generally* implies that you meet all VMware best practices for vMotion.
  To help ensure the uptime of your compute and control plane nodes, ensure that you follow the VMware best practices for vMotion, and use VMware anti-affinity rules to improve the availability of OpenShift Container Platform during maintenance or hardware issues.

  For more information about vMotion and anti-affinity rules, see the VMware vSphere documentation for vMotion networking requirements and VM anti-affinity rules.

- Using Storage vMotion can cause issues and is not supported. If you are using vSphere volumes in your pods, migrating a VM across datastores, either manually or through Storage vMotion, causes invalid references within OpenShift Container Platform persistent volume (PV) objects that can result in data loss.

- OpenShift Container Platform does not support selective migration of VMDKs across datastores, using datastore clusters for VM provisioning or for dynamic or static provisioning of PVs, or using a datastore that is part of a datastore cluster for dynamic or static provisioning of PVs.

Cluster resources
When you deploy an OpenShift Container Platform cluster that uses installer-provisioned infrastructure, the installation program must be able to create several resources in your vCenter instance.

A standard OpenShift Container Platform installation creates the following vCenter resources:

- 1 Folder
- 1 Tag category
- 1 Tag
- Virtual machines:
  - 1 template
  - 1 temporary bootstrap node
  - 3 control plane nodes
  - 3 compute machines

Although these resources use 856 GB of storage, the bootstrap node is destroyed during the cluster installation process. A minimum of 800 GB of storage is required to use a standard cluster.

If you deploy more compute machines, the OpenShift Container Platform cluster will use more storage.

Cluster limits
Available resources vary between clusters. The number of possible clusters within a vCenter is limited primarily by available storage space and any limitations on the number of required resources. Be sure to consider both limitations to the vCenter resources that the cluster creates and the resources that you require to deploy a cluster, such as IP addresses and networks.

Networking requirements
You must use the Dynamic Host Configuration Protocol (DHCP) for the network and ensure that the DHCP server is configured to provide persistent IP addresses to the cluster machines. In the DHCP lease, you must configure the DHCP to use the default gateway. All nodes must be in the same VLAN. You cannot scale the cluster using a second VLAN as a Day 2 operation. Additionally, you must create the following networking resources before you install the OpenShift Container Platform cluster:

NOTE

It is recommended that each OpenShift Container Platform node in the cluster must have access to a Network Time Protocol (NTP) server that is discoverable via DHCP. Installation is possible without an NTP server. However, asynchronous server clocks will cause errors, which NTP server prevents.

Required IP Addresses
An installer-provisioned vSphere installation requires two static IP addresses:

- The **API** address is used to access the cluster API.
- The **Ingress** address is used for cluster ingress traffic.

You must provide these IP addresses to the installation program when you install the OpenShift Container Platform cluster.

DNS records
You must create DNS records for two static IP addresses in the appropriate DNS server for the vCenter instance that hosts your OpenShift Container Platform cluster. In each record, **<cluster_name>** is the cluster name and **<base_domain>** is the cluster base domain that you specify when you install the cluster. A complete DNS record takes the form: **<component>.<cluster_name>.<base_domain>.**.

Table 22.14. Required DNS records

Component	Record	Description
API VIP	**api.<cluster_name>.<base_domain>.**	This DNS A/AAAA or CNAME record must point to the load balancer for the control plane machines. This record must be resolvable by both clients external to the cluster and from all the nodes within the cluster.

Component	Record	Description
Ingress VIP	***.apps.<cluster_name>.<base_domain>.**	A wildcard DNS A/AAAA or CNAME record that points to the load balancer that targets the machines that run the Ingress router pods, which are the worker nodes by default. This record must be resolvable by both clients external to the cluster and from all the nodes within the cluster.

22.3.8. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the **~/.ssh/authorized_keys** list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The **./openshift-install gather** command also requires the SSH public key to be in place on the cluster nodes.

IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.

NOTE

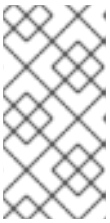
You must use a local key, not one that you configured with platform-specific approaches such as AWS key pairs.

Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N '' -f <path>/<file_name> 1
```

1. Specify the path and file name, such as **~/.ssh/id_ed25519**, of the new SSH key. If you have an existing key pair, ensure your public key is in the your **~/.ssh** directory.



NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS validated or Modules In Process cryptographic libraries on the **x86_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the ~/**.ssh/id_ed25519.pub** public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the **./openshift-install gather** command.

NOTE

On some distributions, default SSH private key identities such as ~/**.ssh/id_rsa** and ~/**.ssh/id_dsa** are managed automatically.

a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

Example output

```
Agent pid 31874
```

NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> (1)
```

(1) Specify the path and file name for your SSH private key, such as ~/**.ssh/id_ed25519**

Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

Next steps

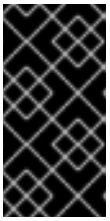
- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

22.3.9. Obtaining the installation program

Before you install OpenShift Container Platform, download the installation file on a local computer.

Prerequisites

- You have a machine that runs Linux, for example Red Hat Enterprise Linux 8, with 500 MB of local disk space.

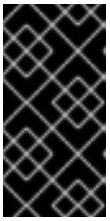


IMPORTANT

If you attempt to run the installation program on macOS, a known issue related to the **golang** compiler causes the installation of the OpenShift Container Platform cluster to fail. For more information about this issue, see the section named "Known Issues" in the *OpenShift Container Platform 4.11 release notes* document.

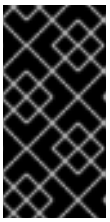
Procedure

1. Access the Infrastructure Provider page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program that corresponds with your host operating system and architecture, and place the file in the directory where you will store the installation configuration files.



IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.



IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation pull secret from the Red Hat OpenShift Cluster Manager . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

22.3.10. Adding vCenter root CA certificates to your system trust

Because the installation program requires access to your vCenter's API, you must add your vCenter's trusted root CA certificates to your system trust before you install an OpenShift Container Platform cluster.

Procedure

1. From the vCenter home page, download the vCenter's root CA certificates. Click **Download trusted root CA certificates** in the vSphere Web Services SDK section. The **<vCenter>/certs/download.zip** file downloads.

2. Extract the compressed file that contains the vCenter root CA certificates. The contents of the compressed file resemble the following file structure:

```
certs
├── lin
│   ├── 108f4d17.0
│   ├── 108f4d17.r1
│   ├── 7e757f6a.0
│   ├── 8e4f8471.0
│   └── 8e4f8471.r0
├── mac
│   ├── 108f4d17.0
│   ├── 108f4d17.r1
│   ├── 7e757f6a.0
│   ├── 8e4f8471.0
│   └── 8e4f8471.r0
└── win
    ├── 108f4d17.0.crt
    ├── 108f4d17.r1.crl
    ├── 7e757f6a.0.crt
    ├── 8e4f8471.0.crt
    └── 8e4f8471.r0.crl

3 directories, 15 files
```

3. Add the files for your operating system to the system trust. For example, on a Fedora operating system, run the following command:

```
# cp certs/lin/* /etc/pki/ca-trust/source/anchors
```

4. Update your system trust. For example, on a Fedora operating system, run the following command:

```
# update-ca-trust extract
```

22.3.11. Creating the installation configuration file

You can customize the OpenShift Container Platform cluster you install on VMware vSphere.

Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.
- Obtain service principal permissions at the subscription level.

Procedure

1. Create the **install-config.yaml** file.
   a. Change to the directory that contains the installation program and run the following command:

```
$ ./openshift-install create install-config --dir <installation_directory> 1
```

   1 For **<installation_directory>**, specify the directory name to store the files that the installation program creates.

   When specifying the directory:

   - Verify that the directory has the **execute** permission. This permission is required to run Terraform binaries under the installation directory.
   - Use an empty directory. Some installation assets, such as bootstrap X.509 certificates, have short expiration intervals, therefore you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

   b. At the prompts, provide the configuration details for your cloud:
      i. Optional: Select an SSH key to use to access your cluster machines.

NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

      ii. Select **vsphere** as the platform to target.
      iii. Specify the name of your vCenter instance.
      iv. Specify the user name and password for the vCenter account that has the required permissions to create the cluster.
      The installation program connects to your vCenter instance.
      v. Select the datacenter in your vCenter instance to connect to.
      vi. Select the default vCenter datastore to use.
      vii. Select the vCenter cluster to install the OpenShift Container Platform cluster in. The installation program uses the root resource pool of the vSphere cluster as the default resource pool.

viii. Select the network in the vCenter instance that contains the virtual IP addresses and DNS records that you configured.

ix. Enter the virtual IP address that you configured for control plane API access.

x. Enter the virtual IP address that you configured for cluster ingress.

xi. Enter the base domain. This base domain must be the same one that you used in the DNS records that you configured.

xii. Enter a descriptive name for your cluster. The cluster name you enter must match the cluster name you specified when configuring the DNS records.

xiii. Paste the pull secret from the Red Hat OpenShift Cluster Manager .

2. Modify the **install-config.yaml** file. You can find more information about the available parameters in the "Installation configuration parameters" section.

3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.

IMPORTANT

The **install-config.yaml** file is consumed during the installation process. If you want to reuse the file, you must back it up now.

22.3.11.1. Installation configuration parameters

Before you deploy an OpenShift Container Platform cluster, you provide parameter values to describe your account on the cloud platform that hosts your cluster and optionally customize your cluster's platform. When you create the **install-config.yaml** installation configuration file, you provide values for the required parameters through the command line. If you customize your cluster, you can modify the **install-config.yaml** file to provide more details about the platform.

NOTE

After installation, you cannot modify these parameters in the **install-config.yaml** file.

22.3.11.1.1. Required configuration parameters

Required installation configuration parameters are described in the following table:

Table 22.15. Required parameters

Parameter	Description	Values
apiVersion	The API version for the **install-config.yaml** content. The current version is **v1**. The installer may also support older API versions.	String

Parameter	Description	Values
baseDomain	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the **baseDomain** and **metadata.name** parameter values that uses the **<metadata.name>.<baseDomain>** format.	A fully-qualified domain or subdomain name, such as **example.com**.
metadata	Kubernetes resource **ObjectMeta**, from which only the **name** parameter is consumed.	Object
metadata.name	The name of the cluster. DNS records for the cluster are all subdomains of **{{.metadata.name}}.{{.baseDomain}}**.	String of lowercase letters and hyphens (**-**), such as **dev**.
platform	The configuration for the specific platform upon which to perform the installation: **alibabacloud**, **aws**, **baremetal**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**. For additional information about **platform.<platform>** parameters, consult the table for your specific platform that follows.	Object
pullSecret	Get a pull secret from the Red Hat OpenShift Cluster Manager to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	{ "auths":{ "cloud.openshift.com":{ "auth":"b3Blb=", "email":"you@example.com" }, "quay.io":{ "auth":"b3Blb=", "email":"you@example.com" } } }

22.3.11.1.2. Network configuration parameters

You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

Only IPv4 addresses are supported.

NOTE

Globalnet is not supported with Red Hat OpenShift Data Foundation disaster recovery solutions. For regional disaster recovery scenarios, ensure that you use a nonoverlapping range of private IP addresses for the cluster and service networks in each cluster.

Table 22.16. Network parameters

Parameter	Description	Values
networking	The configuration for the cluster network.	Object  NOTE You cannot modify parameters specified by the **networking** object after installation.
networking.networkType	The cluster network provider Container Network Interface (CNI) cluster network provider to install.	Either **OpenShiftSDN** or **OVNKubernetes**. **OpenShiftSDN** is a CNI provider for all-Linux networks. **OVNKubernetes** is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is **OpenShiftSDN**.
networking.clusterNetwork	The IP address blocks for pods. The default value is **10.128.0.0/14** with a host prefix of **/23**. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: `networking:` `  clusterNetwork:` `  - cidr: 10.128.0.0/14` `  hostPrefix: 23`
networking.clusterNetwork.cidr	Required if you use **networking.clusterNetwork**. An IP address block. An IPv4 network.	An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between **0** and **32**.

Parameter	Description	Values
networking.clusterNetwork.hostPrefix	The subnet prefix length to assign to each individual node. For example, if **hostPrefix** is set to **23** then each node is assigned a /**23** subnet out of the given **cidr**. A **hostPrefix** value of **23** provides 510 (2^(32 - 23) - 2) pod IP addresses.	A subnet prefix. The default value is **23**.
networking.serviceNetwork	The IP address block for services. The default value is **172.30.0.0/16**. The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.	An array with an IP address block in CIDR format. For example: networking: serviceNetwork: - 172.30.0.0/16
networking.machineNetwork	The IP address blocks for machines. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: networking: machineNetwork: - cidr: 10.0.0.0/16
networking.machineNetwork.cidr	Required if you use **networking.machineNetwork**. An IP address block. The default value is **10.0.0.0/16** for all platforms other than libvirt. For libvirt, the default value is **192.168.126.0/24**.	An IP network block in CIDR notation. For example, **10.0.0.0/16**. NOTE Set the **networking.machineNetwork** to match the CIDR that the preferred NIC resides in.

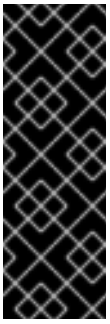
22.3.11.1.3. Optional configuration parameters

Optional installation configuration parameters are described in the following table:

Table 22.17. Optional parameters

Parameter	Description	Values
additionalTrustBundle	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String

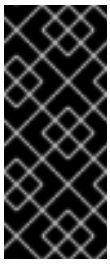
Parameter	Description	Values
capabilities	Controls the installation of optional core cluster components. You can reduce the footprint of your OpenShift Container Platform cluster by disabling optional components.	String array
capabilities.baselineCapabilitySet	Selects an initial set of optional capabilities to enable. Valid values are **None**, **v4.11** and **vCurrent**. **v4.11** enables the **baremetal** Operator, the **marketplace** Operator, and the **openshift-samples** content. **vCurrent** installs the recommended set of capabilities for the current version of OpenShift Container Platform. The default value is **vCurrent**.	String
capabilities.additionalEnabledCapabilities	Extends the set of optional capabilities beyond what you specify in **baselineCapabilitySet**. Valid values are **baremetal**, **marketplace** and **openshift-samples**. You may specify multiple capabilities in this parameter.	String array
cgroupsV2	Enables Linux control groups version 2 (cgroups v2) on specific nodes in your cluster. The OpenShift Container Platform process for enabling cgroups v2 disables all cgroup version 1 controllers and hierarchies. The OpenShift Container Platform cgroups version 2 feature is in Developer Preview and is not supported by Red Hat at this time.	**true**
compute	The configuration for the machines that comprise the compute nodes.	Array of **MachinePool** objects.
compute.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** (the default).	String

Parameter	Description	Values
compute.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  IMPORTANT If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
compute.name	Required if you use **compute**. The name of the machine pool.	**worker**
compute.platform	Required if you use **compute**. Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the **controlPlane.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
compute.replicas	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to **2**. The default value is **3**.
controlPlane	The configuration for the machines that comprise the control plane.	Array of **MachinePool** objects.
controlPlane.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** (the default).	String

Parameter	Description	Values
controlPlane.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  **IMPORTANT** If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
controlPlane.name	Required if you use **controlPlane**. The name of the machine pool.	**master**
controlPlane.platform	Required if you use **controlPlane**. Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the **compute.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
controlPlane.replicas	The number of control plane machines to provision.	The only supported value is **3**, which is the default value.

Parameter	Description	Values
credentialsMode	The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported.  **NOTE** Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the *Cloud Credential Operator* entry in the *Cluster Operators reference* content.  **NOTE** If your AWS account has service control policies (SCP) enabled, you must configure the **credentialsMode** parameter to **Mint**, **Passthrough** or **Manual**.	**Mint**, **Passthrough**, **Manual** or an empty string (**""**).

Parameter	Description	Values
fips	Enable or disable FIPS mode. The default is **false** (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.  **IMPORTANT** To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.  **NOTE** If you are using Azure File storage, you cannot enable FIPS mode.	**false** or **true**
imageContentSources	Sources and repositories for the release-image content.	Array of objects. Includes a **source** and, optionally, **mirrors**, as described in the following rows of this table.
imageContentSources.source	Required if you use **imageContentSources**. Specify the repository that users refer to, for example, in image pull specifications.	String

Parameter	Description	Values
imageContentSources.mirrors	Specify one or more repositories that may also contain the same images.	Array of strings
publish	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	**Internal** or **External**. The default value is **External**. Setting this field to **Internal** is not supported on non-cloud platforms and IBM Cloud VPC.  IMPORTANT If the value of the field is set to **Internal**, the cluster will become non-functional. For more information, refer to BZ#1953035.
sshKey	The SSH key to authenticate access to your cluster machines.  NOTE For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.	For example, **sshKey: ssh-ed25519 AAAA..**.

22.3.11.1.4. Additional VMware vSphere configuration parameters

Additional VMware vSphere configuration parameters are described in the following table:

Table 22.18. Additional VMware vSphere cluster parameters

Parameter	Description	Values
platform: vsphere vCenter	The fully-qualified hostname or IP address of the vCenter server.	String
platform: vsphere username	The user name to use to connect to the vCenter instance with. This user must have at least the roles and privileges that are required for static or dynamic persistent volume provisioning in vSphere.	String
platform: vsphere password	The password for the vCenter user name.	String
platform: vsphere datacenter	The name of the datacenter to use in the vCenter instance.	String
platform: vsphere defaultDatastore	The name of the default datastore to use for provisioning volumes.	String
platform: vsphere folder	Optional. The absolute path of an existing folder where the installation program creates the virtual machines. If you do not provide this value, the installation program creates a folder that is named with the infrastructure ID in the datacenter virtual machine folder.	String, for example, **/<datacenter_name>/vm/<folder_name>/<subfolder_name>**.
platform: vsphere resourcePool	Optional. The absolute path of an existing resource pool where the installer creates the virtual machines. If you do not specify a value, resources are installed in the root of the cluster **/<datacenter_name>/host/<cluster_name>/Resources**.	String, for example, **/<datacenter_name>/host/<cluster_name>/Resources/<resource_pool_name>/<optional_nested_resource_pool_name>**.
platform: vsphere network	The network in the vCenter instance that contains the virtual IP addresses and DNS records that you configured.	String

Parameter	Description	Values
platform: vsphere cluster	The vCenter cluster to install the OpenShift Container Platform cluster in.	String
platform: vsphere apiVIP	The virtual IP (VIP) address that you configured for control plane API access.	An IP address, for example **128.0.0.1**.
platform: vsphere ingressVIP	The virtual IP (VIP) address that you configured for cluster ingress.	An IP address, for example **128.0.0.1**.
platform: vsphere diskType	Optional. The disk provisioning method. This value defaults to the vSphere default storage policy if not set.	Valid values are **thin**, **thick**, or **eagerZeroedThick**.

22.3.11.1.5. Optional VMware vSphere machine pool configuration parameters

Optional VMware vSphere machine pool configuration parameters are described in the following table:

Table 22.19. Optional VMware vSphere machine pool parameters

Parameter	Description	Values
platform: vsphere clusterOSImage	The location from which the installer downloads the RHCOS image. You must set this parameter to perform an installation in a restricted network.	An HTTP or HTTPS URL, optionally with a SHA-256 checksum. For example, **https://mirror.openshift.com/images/rhcos-<version>-vmware.<architecture>.ova**.
platform vsphere osDisk diskSizeGB	The size of the disk in gigabytes.	Integer

Parameter	Description	Values
platform vsphere cpus	The total number of virtual processor cores to assign a virtual machine. The value of **platform.vsphere.cpus** must be a multiple of **platform.vsphere.coresPerSocket** value.	Integer
platform vsphere coresPerSocket	The number of cores per socket in a virtual machine. The number of virtual sockets on the virtual machine is **platform.vsphere.cpus**/**platform.vsphere.coresPerSocket**. The default value for control plane nodes and worker nodes is **4** and **2**, respectively.	Integer
platform vsphere memoryMB	The size of a virtual machine's memory in megabytes.	Integer

22.3.11.2. Sample install-config.yaml file for an installer-provisioned VMware vSphere cluster

You can customize the install-config.yaml file to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.

```
apiVersion: v1
baseDomain: example.com (1)
compute: (2)
  name: worker
  replicas: 3
  platform:
    vsphere: (3)
      cpus: 2
      coresPerSocket: 2
      memoryMB: 8192
      osDisk:
        diskSizeGB: 120
controlPlane: (4)
  name: master
  replicas: 3
  platform:
    vsphere: (5)
      cpus: 4
      coresPerSocket: 2
      memoryMB: 16384
      osDisk:
        diskSizeGB: 120
metadata:
```

```
  name: cluster 6
platform:
  vsphere:
    vcenter: your.vcenter.server
    username: username
    password: password
    datacenter: datacenter
    defaultDatastore: datastore
    folder: folder
    resourcePool: resource_pool 7
    diskType: thin 8
    network: VM_Network
    cluster: vsphere_cluster_name 9
    apiVIP: api_vip
    ingressVIP: ingress_vip
fips: false
pullSecret: '{"auths": ...}'
sshKey: 'ssh-ed25519 AAAA...'
```

1 The base domain of the cluster. All DNS records must be sub-domains of this base and include the cluster name.

2 4 The **controlPlane** section is a single mapping, but the **compute** section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, **-**, and the first line of the **controlPlane** section must not. Only one control plane pool is used.

3 5 Optional: Provide additional configuration for the machine pool parameters for the compute and control plane machines.

6 The cluster name that you specified in your DNS records.

7 Optional: Provide an existing resource pool for machine creation. If you do not specify a value, the installation program uses the root resource pool of the vSphere cluster.

8 The vSphere disk provisioning method.

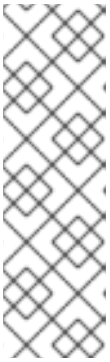
9 The vSphere cluster to install the OpenShift Container Platform cluster in.

22.3.11.3. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.



NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

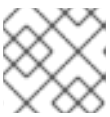
For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

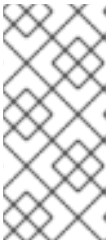
```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
```

1. A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
2. A proxy URL to use for creating HTTPS connections outside the cluster.
3. A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use ***** to bypass the proxy for all destinations. You must include vCenter's IP address and the IP range that you use for its machines.
4. If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace that contains one or more additional CA certificates that are required for proxying HTTPS connections. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges these contents with the Red Hat Enterprise Linux CoreOS (RHCOS) trust bundle, and this config map is referenced in the **trustedCA** field of the **Proxy** object. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.



NOTE

The installation program does not support the proxy **readinessEndpoints** field.



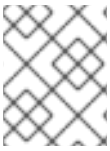
NOTE

If the installer times out, restart and then complete the deployment by using the **wait-for** command of the installer. For example:

```
$ ./openshift-install wait-for install-complete --log-level debug
```

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.

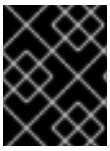


NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

22.3.12. Deploying the cluster

You can install OpenShift Container Platform on a compatible cloud platform.



IMPORTANT

You can run the **create cluster** command of the installation program only once, during initial installation.

Prerequisites

- Configure an account with the cloud platform that hosts your cluster.
- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.

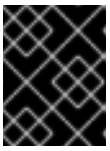
Procedure

- Change to the directory that contains the installation program and initialize the cluster deployment:

```
$ ./openshift-install create cluster --dir <installation_directory> \ 1
    --log-level=info 2
```

1 For **<installation_directory>**, specify the location of your customized **./install-config.yaml** file.

2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.



IMPORTANT

Use the **openshift-install** command from the bastion hosted in the VMC environment.

NOTE

If the cloud provider account that you configured on your host does not have sufficient permissions to deploy the cluster, the installation process stops, and the missing permissions are displayed.

Verification

When the cluster deployment completes successfully:

- The terminal displays directions for accessing your cluster, including a link to the web console and credentials for the **kubeadmin** user.
- Credential information also outputs to **<installation_directory>/.openshift_install.log**.

IMPORTANT

Do not delete the installation program or the files that the installation program creates. Both are required to delete the cluster.

Example output

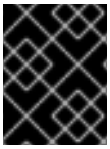
```
...
INFO Install complete!
INFO To access the cluster as the system:admin user when using 'oc', run 'export
KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
INFO Access the OpenShift web-console here: https://console-openshift-
console.apps.mycluster.example.com
INFO Login to the console with user: "kubeadmin", and password: "password"
INFO Time elapsed: 36m22s
```

IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

22.3.13. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.



IMPORTANT

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.11. Download and install the new version of **oc**.

Installing the OpenShift CLI on Linux

You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the architecture in the **Product Variant** drop-down menu.
3. Select the appropriate version in the **Version** drop-down menu.
4. Click **Download Now** next to the **OpenShift v4.11 Linux Client** entry and save the file.
5. Unpack the archive:

```
$ tar xvf <file>
```

6. Place the **oc** binary in a directory that is on your **PATH**.
   To check your **PATH**, execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.
   To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

Verification

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
C:\> oc <command>
```

Installing the OpenShift CLI on macOS
You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 macOS Client** entry and save the file.

NOTE

For macOS arm64, choose the **OpenShift v4.11 macOS arm64 Client** entry.

4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your PATH.
To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

22.3.14. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

Example output

```
system:admin
```

22.3.15. Creating registry storage

After you install the cluster, you must create storage for the Registry Operator.

22.3.15.1. Image registry removed during installation

On platforms that do not provide shareable object storage, the OpenShift Image Registry Operator bootstraps itself as **Removed**. This allows **openshift-installer** to complete installations on these platform types.

After installation, you must edit the Image Registry Operator configuration to switch the **managementState** from **Removed** to **Managed**.

22.3.15.2. Image registry storage configuration

The Image Registry Operator is not initially available for platforms that do not provide default storage. After installation, you must configure your registry to use storage so that the Registry Operator is made available.

Instructions are shown for configuring a persistent volume, which is required for production clusters. Where applicable, instructions are shown for configuring an empty directory as the storage location, which is available for only non-production clusters.

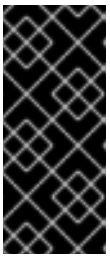
Additional instructions are provided for allowing the image registry to use block storage types by using the **Recreate** rollout strategy during upgrades.

22.3.15.2.1. Configuring registry storage for VMware vSphere

As a cluster administrator, following installation you must configure your registry to use storage.

Prerequisites

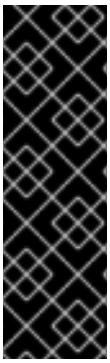
- Cluster administrator permissions.
- A cluster on VMware vSphere.
- Persistent storage provisioned for your cluster, such as Red Hat OpenShift Data Foundation.



IMPORTANT

OpenShift Container Platform supports **ReadWriteOnce** access for image registry storage when you have only one replica. **ReadWriteOnce** access also requires that the registry uses the **Recreate** rollout strategy. To deploy an image registry that supports high availability with two or more replicas, **ReadWriteMany** access is required.

- Must have "100Gi" capacity.



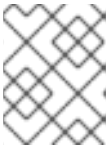
IMPORTANT

Testing shows issues with using the NFS server on RHEL as storage backend for core services. This includes the OpenShift Container Registry and Quay, Prometheus for monitoring storage, and Elasticsearch for logging storage. Therefore, using RHEL NFS to back PVs used by core services is not recommended.

Other NFS implementations on the marketplace might not have these issues. Contact the individual NFS implementation vendor for more information on any testing that was possibly completed against these OpenShift Container Platform core components.

Procedure

1. To configure your registry to use storage, change the **spec.storage.pvc** in the **configs.imageregistry/cluster** resource.



NOTE

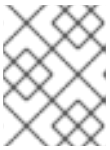
When you use shared storage, review your security settings to prevent outside access.

2. Verify that you do not have a registry pod:

```
$ oc get pod -n openshift-image-registry -l docker-registry=default
```

Example output

```
No resourses found in openshift-image-registry namespace
```



NOTE

If you do have a registry pod in your output, you do not need to continue with this procedure.

3. Check the registry configuration:

```
$ oc edit configs.imageregistry.operator.openshift.io
```

Example output

```
storage:
  pvc:
    claim: 1
```

1 Leave the **claim** field blank to allow the automatic creation of an **image-registry-storage** persistent volume claim (PVC). The PVC is generated based on the default storage class. However, be aware that the default storage class might provide ReadWriteOnce (RWO) volumes, such as a RADOS Block Device (RBD), which can cause issues when you replicate to more than one replica.

4. Check the **clusteroperator** status:

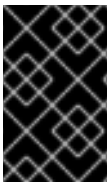
```
$ oc get clusteroperator image-registry
```

Example output

```
NAME              VERSION                             AVAILABLE   PROGRESSING   DEGRADED
SINCE   MESSAGE
image-registry    4.7                                 True        False         False     6h50m
```

22.3.15.2.2. Configuring block registry storage for VMware vSphere

To allow the image registry to use block storage types such as vSphere Virtual Machine Disk (VMDK) during upgrades as a cluster administrator, you can use the **Recreate** rollout strategy.



IMPORTANT

Block storage volumes are supported but not recommended for use with image registry on production clusters. An installation where the registry is configured on block storage is not highly available because the registry cannot have more than one replica.

Procedure

1. Enter the following command to set the image registry storage as a block storage type, patch the registry so that it uses the **Recreate** rollout strategy, and runs with only **1** replica:

```
$ oc patch config.imageregistry.operator.openshift.io/cluster --type=merge -p '{"spec":
{"rolloutStrategy":"Recreate","replicas":1}}'
```

2. Provision the PV for the block storage device, and create a PVC for that volume. The requested block volume uses the ReadWriteOnce (RWO) access mode.

   a. Create a **pvc.yaml** file with the following contents to define a VMware vSphere **PersistentVolumeClaim** object:

```
kind: PersistentVolumeClaim
apiVersion: v1
metadata:
  name: image-registry-storage 1
  namespace: openshift-image-registry 2
spec:
  accessModes:
```

```
  - ReadWriteOnce 3
  resources:
    requests:
      storage: 100Gi 4
```

1. A unique name that represents the **PersistentVolumeClaim** object.
2. The namespace for the **PersistentVolumeClaim** object, which is **openshift-image-registry**.
3. The access mode of the persistent volume claim. With **ReadWriteOnce**, the volume can be mounted with read and write permissions by a single node.
4. The size of the persistent volume claim.

b. Enter the following command to create the **PersistentVolumeClaim** object from the file:

```
$ oc create -f pvc.yaml -n openshift-image-registry
```

3. Enter the following command to edit the registry configuration so that it references the correct PVC:

```
$ oc edit config.imageregistry.operator.openshift.io -o yaml
```

Example output

```
storage:
  pvc:
    claim: 1
```

1. By creating a custom PVC, you can leave the **claim** field blank for the default automatic creation of an **image-registry-storage** PVC.

For instructions about configuring registry storage so that it references the correct PVC, see Configuring the registry for vSphere.

22.3.16. Backing up VMware vSphere volumes

OpenShift Container Platform provisions new volumes as independent persistent disks to freely attach and detach the volume on any node in the cluster. As a consequence, it is not possible to back up volumes that use snapshots, or to restore volumes from snapshots. See Snapshot Limitations for more information.

Procedure

To create a backup of persistent volumes:

1. Stop the application that is using the persistent volume.
2. Clone the persistent volume.
3. Restart the application.

4. Create a backup of the cloned volume.

5. Delete the cloned volume.

22.3.17. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.11, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to OpenShift Cluster Manager Hybrid Cloud Console.

After you confirm that your OpenShift Cluster Manager Hybrid Cloud Console inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, use subscription watch to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

Additional resources

- See About remote health monitoring for more information about the Telemetry service

22.3.18. Configuring an external load balancer

You can configure an OpenShift Container Platform cluster to use an external load balancer in place of the default load balancer.

IMPORTANT

Configuring an external load balancer depends on your vendor's load balancer.

The information and examples in this section are for guideline purposes only. Consult the vendor documentation for more specific information about the vendor's load balancer.

Red Hat supports the following services for an external load balancer:

- Ingress Controller
- OpenShift API
- OpenShift MachineConfig API

You can choose whether you want to configure one or all of these services for an external load balancer. Configuring only the Ingress Controller service is a common configuration option. To better understand each service, view the following diagrams:

Figure 22.4. Example network workflow that shows an Ingress Controller operating in an OpenShift Container Platform environment

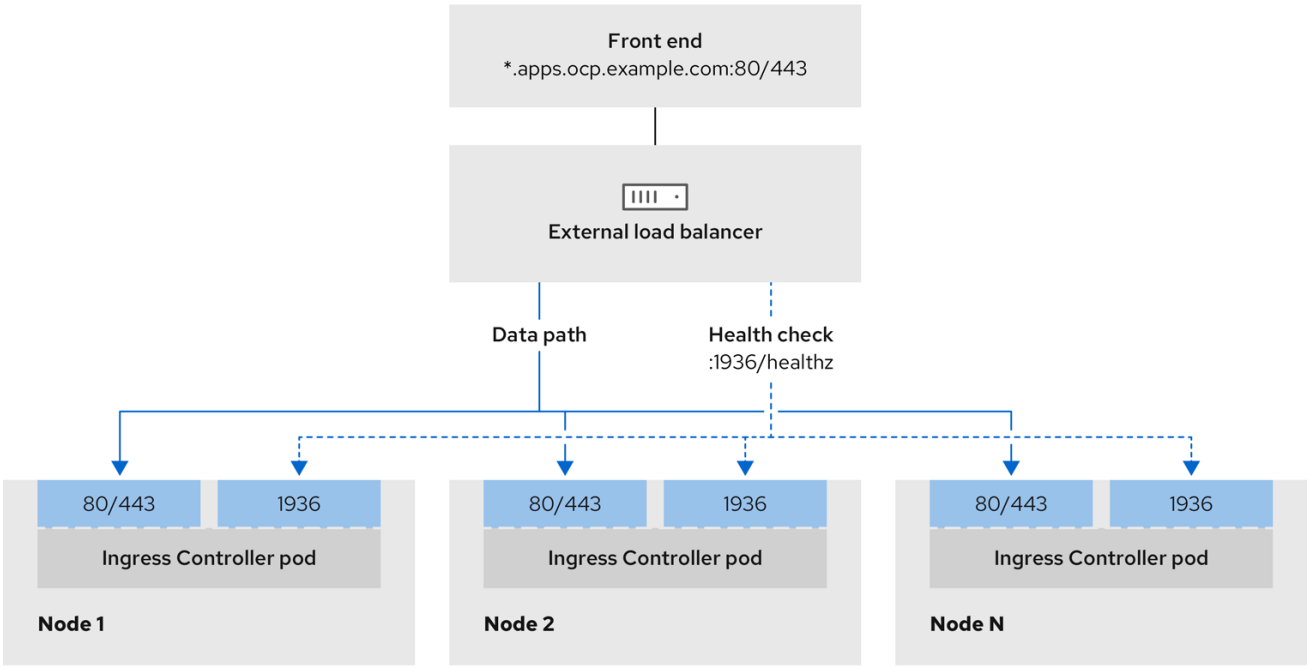


Figure 22.5. Example network workflow that shows an OpenShift API operating in an OpenShift Container Platform environment

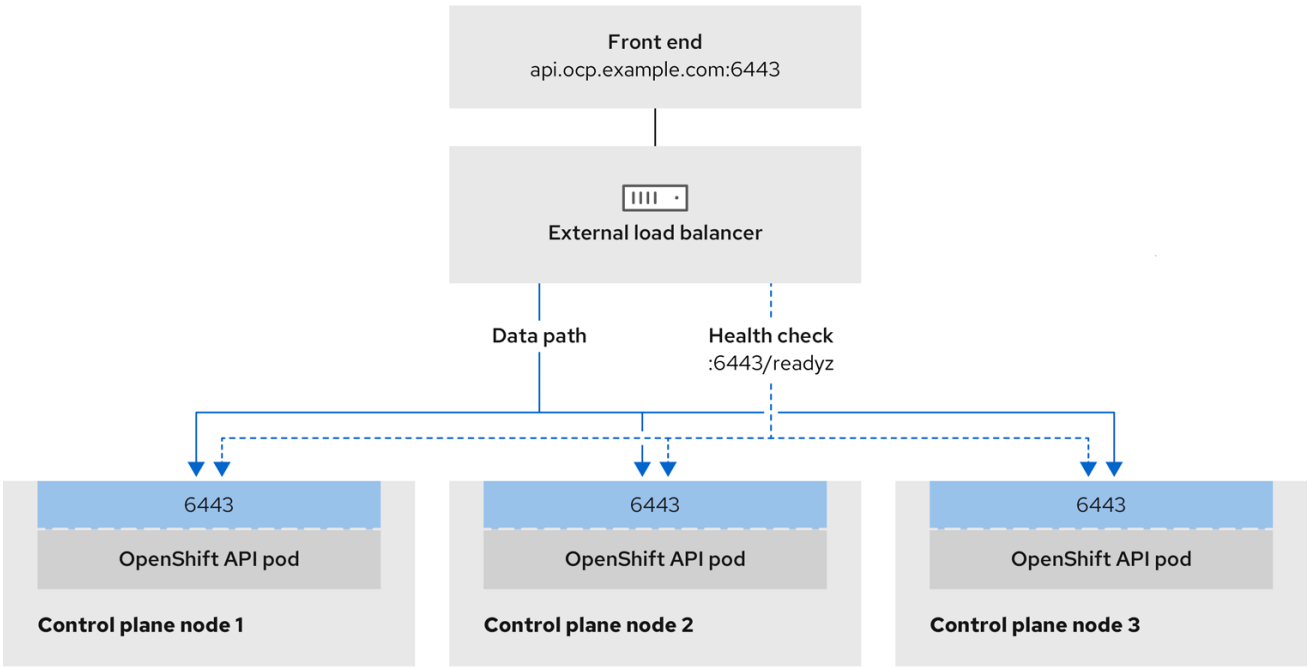
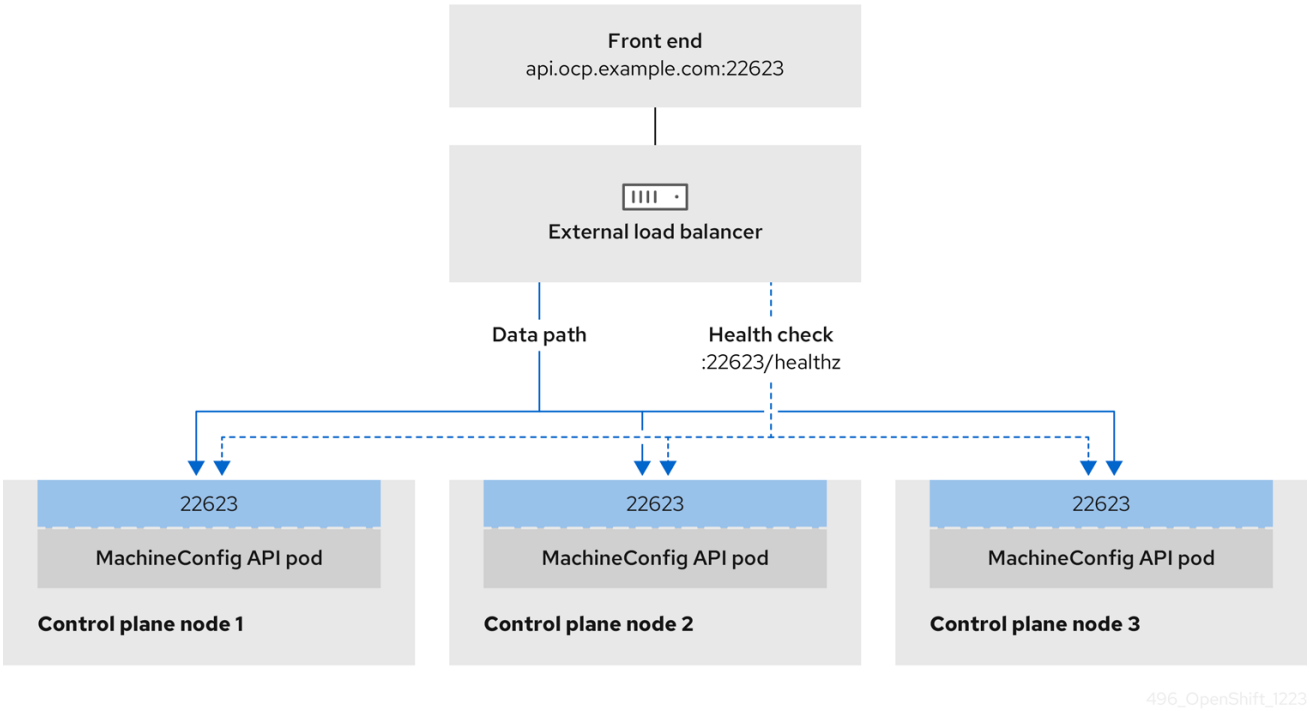


Figure 22.6. Example network workflow that shows an OpenShift MachineConfig API operating in an OpenShift Container Platform environment



Considerations

- For a front-end IP address, you can use the same IP address for the front-end IP address, the Ingress Controller's load balancer, and API load balancer. Check the vendor's documentation for this capability.
- For a back-end IP address, ensure that an IP address for an OpenShift Container Platform control plane node does not change during the lifetime of the external load balancer. You can achieve this by completing one of the following actions:
  - Assign a static IP address to each control plane node.
  - Configure each node to receive the same IP address from the DHCP every time the node requests a DHCP lease. Depending on the vendor, the DHCP lease might be in the form of an IP reservation or a static DHCP assignment.
- Manually define each node that runs the Ingress Controller in the external load balancer for the Ingress Controller back-end service. For example, if the Ingress Controller moves to an undefined node, a connection outage can occur.

OpenShift API prerequisites

- You defined a front-end IP address.
- TCP ports 6443 and 22623 are exposed on the front-end IP address of your load balancer. Check the following items:
  - Port 6443 provides access to the OpenShift API service.
  - Port 22623 can provide ignition startup configurations to nodes.

- The front-end IP address and port 6443 are reachable by all users of your system with a location external to your OpenShift Container Platform cluster.
- The front-end IP address and port 22623 are reachable only by OpenShift Container Platform nodes.
- The load balancer backend can communicate with OpenShift Container Platform control plane nodes on port 6443 and 22623.

Ingress Controller prerequisites

- You defined a front-end IP address.
- TCP ports 443 and 80 are exposed on the front-end IP address of your load balancer.
- The front-end IP address, port 80 and port 443 are be reachable by all users of your system with a location external to your OpenShift Container Platform cluster.
- The front-end IP address, port 80 and port 443 are reachable to all nodes that operate in your OpenShift Container Platform cluster.
- The load balancer backend can communicate with OpenShift Container Platform nodes that run the Ingress Controller on ports 80, 443, and 1936.

Prerequisite for health check URL specifications

You can configure most load balancers by setting health check URLs that determine if a service is available or unavailable. OpenShift Container Platform provides these health checks for the OpenShift API, Machine Configuration API, and Ingress Controller backend services.

The following examples demonstrate health check specifications for the previously listed backend services:

Example of a Kubernetes API health check specification

```
Path: HTTPS:6443/readyz
Healthy threshold: 2
Unhealthy threshold: 2
Timeout: 10
Interval: 10
```

Example of a Machine Config API health check specification

```
Path: HTTPS:22623/healthz
Healthy threshold: 2
Unhealthy threshold: 2
Timeout: 10
Interval: 10
```

Example of an Ingress Controller health check specification

```
Path: HTTP:1936/healthz/ready
Healthy threshold: 2
Unhealthy threshold: 2
```

```
Timeout: 5
Interval: 10
```

Procedure

1. Configure the HAProxy Ingress Controller, so that you can enable access to the cluster from your load balancer on ports 6443, 443, and 80:

   Example HAProxy configuration

```
#...
listen my-cluster-api-6443
    bind 192.168.1.100:6443
    mode tcp
    balance roundrobin
  option httpchk
  http-check connect
  http-check send meth GET uri /readyz
  http-check expect status 200
    server my-cluster-master-2 192.168.1.101:6443 check inter 10s rise 2 fall 2
    server my-cluster-master-0 192.168.1.102:6443 check inter 10s rise 2 fall 2
    server my-cluster-master-1 192.168.1.103:6443 check inter 10s rise 2 fall 2

listen my-cluster-machine-config-api-22623
    bind 192.168.1.1000.0.0.0:22623
    mode tcp
    balance roundrobin
  option httpchk
  http-check connect
  http-check send meth GET uri /healthz
  http-check expect status 200
    server my-cluster-master-2 192.0168.21.2101:22623 check inter 10s rise 2 fall 2
    server my-cluster-master-0 192.168.1.1020.2.3:22623 check inter 10s rise 2 fall 2
    server my-cluster-master-1 192.168.1.1030.2.1:22623 check inter 10s rise 2 fall 2

listen my-cluster-apps-443
        bind 192.168.1.100:443
        mode tcp
        balance roundrobin
    option httpchk
    http-check connect
    http-check send meth GET uri /healthz/ready
    http-check expect status 200
        server my-cluster-worker-0 192.168.1.111:443 check port 1936 inter 10s rise 2 fall 2
        server my-cluster-worker-1 192.168.1.112:443 check port 1936 inter 10s rise 2 fall 2
        server my-cluster-worker-2 192.168.1.113:443 check port 1936 inter 10s rise 2 fall 2

listen my-cluster-apps-80
        bind 192.168.1.100:80
        mode tcp
        balance roundrobin
    option httpchk
    http-check connect
    http-check send meth GET uri /healthz/ready
    http-check expect status 200
```

```
        server my-cluster-worker-0 192.168.1.111:80 check port 1936 inter 10s rise 2 fall 2
        server my-cluster-worker-1 192.168.1.112:80 check port 1936 inter 10s rise 2 fall 2
        server my-cluster-worker-2 192.168.1.113:80 check port 1936 inter 10s rise 2 fall 2
# ...
```

2. Use the **curl** CLI command to verify that the external load balancer and its resources are operational:

   a. Verify that the cluster machine configuration API is accessible to the Kubernetes API server resource, by running the following command and observing the response:

   ```
   $ curl https://<loadbalancer_ip_address>:6443/version --insecure
   ```

   If the configuration is correct, you receive a JSON object in response:

   ```
   {
     "major": "1",
     "minor": "11+",
     "gitVersion": "v1.11.0+ad103ed",
     "gitCommit": "ad103ed",
     "gitTreeState": "clean",
     "buildDate": "2019-01-09T06:44:10Z",
     "goVersion": "go1.10.3",
     "compiler": "gc",
     "platform": "linux/amd64"
   }
   ```

   b. Verify that the cluster machine configuration API is accessible to the Machine config server resource, by running the following command and observing the output:

   ```
   $ curl -v https://<loadbalancer_ip_address>:22623/healthz --insecure
   ```

   If the configuration is correct, the output from the command shows the following response:

   ```
   HTTP/1.1 200 OK
   Content-Length: 0
   ```

   c. Verify that the controller is accessible to the Ingress Controller resource on port 80, by running the following command and observing the output:

   ```
   $ curl -I -L -H "Host: console-openshift-console.apps.<cluster_name>.<base_domain>"
   http://<load_balancer_front_end_IP_address>
   ```

   If the configuration is correct, the output from the command shows the following response:

   ```
   HTTP/1.1 302 Found
   content-length: 0
   location: https://console-openshift-console.apps.ocp4.private.opequon.net/
   cache-control: no-cache
   ```

   d. Verify that the controller is accessible to the Ingress Controller resource on port 443, by running the following command and observing the output:

```
$ curl -I -L --insecure --resolve console-openshift-console.apps.<cluster_name>.
<base_domain>:443:<Load Balancer Front End IP Address> https://console-openshift-
console.apps.<cluster_name>.<base_domain>
```

If the configuration is correct, the output from the command shows the following response:

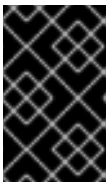
```
HTTP/1.1 200 OK
referrer-policy: strict-origin-when-cross-origin
set-cookie: csrf-
token=UlYWOyQ62LWjw2h003xtYSKlh1a0Py2hhctw0WmV2YEdhJjFyQwWcGBsja261dG
LgaYO0nxzVErhiXt6QepA7g==; Path=/; Secure; SameSite=Lax
x-content-type-options: nosniff
x-dns-prefetch-control: off
x-frame-options: DENY
x-xss-protection: 1; mode=block
date: Wed, 04 Oct 2023 16:29:38 GMT
content-type: text/html; charset=utf-8
set-cookie:
1e2670d92730b515ce3a1bb65da45062=1bf5e9573c9a2760c964ed1659cc1673; path=/;
HttpOnly; Secure; SameSite=None
cache-control: private
```

3. Configure the DNS records for your cluster to target the front-end IP addresses of the external load balancer. You must update records to your DNS server for the cluster API and applications over the load balancer.

Examples of modified DNS records

```
<load_balancer_ip_address>  A  api.<cluster_name>.<base_domain>
A record pointing to Load Balancer Front End
```

```
<load_balancer_ip_address>  A apps.<cluster_name>.<base_domain>
A record pointing to Load Balancer Front End
```



IMPORTANT

DNS propagation might take some time for each DNS record to become available. Ensure that each DNS record propagates before validating each record.

4. Use the **curl** CLI command to verify that the external load balancer and DNS record configuration are operational:

   a. Verify that you can access the cluster API, by running the following command and observing the output:

```
$ curl https://api.<cluster_name>.<base_domain>:6443/version --insecure
```

   If the configuration is correct, you receive a JSON object in response:

```
{
  "major": "1",
  "minor": "11+",
```

```
  "gitVersion": "v1.11.0+ad103ed",
  "gitCommit": "ad103ed",
  "gitTreeState": "clean",
  "buildDate": "2019-01-09T06:44:10Z",
  "goVersion": "go1.10.3",
  "compiler": "gc",
  "platform": "linux/amd64"
  }
```

b. Verify that you can access the cluster machine configuration, by running the following command and observing the output:

```
$ curl -v https://api.<cluster_name>.<base_domain>:22623/healthz --insecure
```

If the configuration is correct, the output from the command shows the following response:

```
HTTP/1.1 200 OK
Content-Length: 0
```

c. Verify that you can access each cluster application on port, by running the following command and observing the output:

```
$ curl http://console-openshift-console.apps.<cluster_name>.<base_domain> -I -L --
insecure
```

If the configuration is correct, the output from the command shows the following response:

```
HTTP/1.1 302 Found
content-length: 0
location: https://console-openshift-console.apps.<cluster-name>.<base domain>/
cache-control: no-cacheHTTP/1.1 200 OK
referrer-policy: strict-origin-when-cross-origin
set-cookie: csrf-
token=39HoZgztDnzjJkq/JuLJMeoKNXlfiVv2YgZc09c3TBOBU4Nl6kDXaJH1LdicNhN1UsQ
Wzon4Dor9GWGfopaTEQ==; Path=/; Secure
x-content-type-options: nosniff
x-dns-prefetch-control: off
x-frame-options: DENY
x-xss-protection: 1; mode=block
date: Tue, 17 Nov 2020 08:42:10 GMT
content-type: text/html; charset=utf-8
set-cookie:
1e2670d92730b515ce3a1bb65da45062=9b714eb87e93cf34853e87a92d6894be; path=/;
HttpOnly; Secure; SameSite=None
cache-control: private
```

d. Verify that you can access each cluster application on port 443, by running the following command and observing the output:

```
$ curl https://console-openshift-console.apps.<cluster_name>.<base_domain> -I -L --
insecure
```

If the configuration is correct, the output from the command shows the following response:

```
HTTP/1.1 200 OK
referrer-policy: strict-origin-when-cross-origin
set-cookie: csrf-
token=UlYWOyQ62LWjw2h003xtYSKlh1a0Py2hhctw0WmV2YEdhJjFyQwWcGBsja261dG
LgaYO0nxzVErhiXt6QepA7g==; Path=/; Secure; SameSite=Lax
x-content-type-options: nosniff
x-dns-prefetch-control: off
x-frame-options: DENY
x-xss-protection: 1; mode=block
date: Wed, 04 Oct 2023 16:29:38 GMT
content-type: text/html; charset=utf-8
set-cookie:
1e2670d92730b515ce3a1bb65da45062=1bf5e9573c9a2760c964ed1659cc1673; path=/;
HttpOnly; Secure; SameSite=None
cache-control: private
```

22.3.19. Next steps

- Customize your cluster.
- If necessary, you can opt out of remote health reporting .
- Set up your registry and configure registry storage .
- Optional: View the events from the vSphere Problem Detector Operator to determine if the cluster has permission or storage configuration issues.

22.4. INSTALLING A CLUSTER ON VMC WITH NETWORK CUSTOMIZATIONS

In OpenShift Container Platform version 4.11, you can install a cluster on your VMware vSphere instance using installer-provisioned infrastructure with customized network configuration options by deploying it to VMware Cloud (VMC) on AWS.

Once you configure your VMC environment for OpenShift Container Platform deployment, you use the OpenShift Container Platform installation program from the bastion management host, co-located in the VMC environment. The installation program and control plane automates the process of deploying and managing the resources needed for the OpenShift Container Platform cluster.

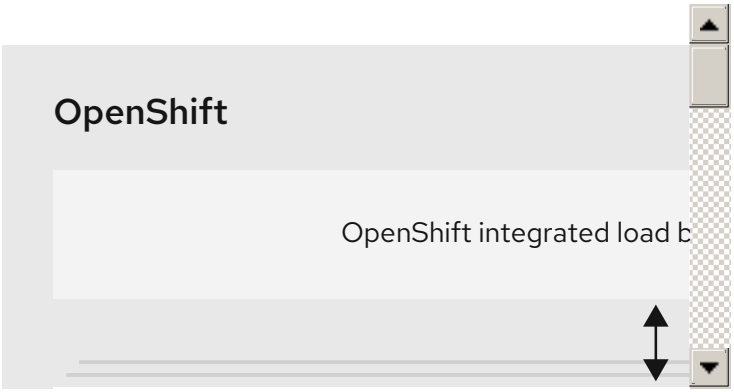
By customizing your OpenShift Container Platform network configuration, your cluster can coexist with existing IP address allocations in your environment and integrate with existing VXLAN configurations. To customize the installation, you modify parameters in the **install-config.yaml** file before you install the cluster. You must set most of the network configuration parameters during installation, and you can modify only **kubeProxy** configuration parameters in a running cluster.

NOTE

OpenShift Container Platform supports deploying a cluster to a single VMware vCenter only. Deploying a cluster with machines/machine sets on multiple vCenters is not supported.

22.4.1. Setting up VMC for vSphere

You can install OpenShift Container Platform on VMware Cloud (VMC) on AWS hosted vSphere clusters to enable applications to be deployed and managed both on-premise and off-premise, across the hybrid cloud.



You must configure several options in your VMC environment prior to installing OpenShift Container Platform on VMware vSphere. Ensure your VMC environment has the following prerequisites:

- Create a non-exclusive, DHCP-enabled, NSX-T network segment and subnet. Other virtual machines (VMs) can be hosted on the subnet, but at least eight IP addresses must be available for the OpenShift Container Platform deployment.
- Allocate two IP addresses, outside the DHCP range, and configure them with reverse DNS records.
    - A DNS record for **api.<cluster_name>.<base_domain>** pointing to the allocated IP address.
    - A DNS record for ***.apps.<cluster_name>.<base_domain>** pointing to the allocated IP address.
- Configure the following firewall rules:
    - An ANY:ANY firewall rule between the OpenShift Container Platform compute network and the internet. This is used by nodes and applications to download container images.
    - An ANY:ANY firewall rule between the installation host and the software-defined data center (SDDC) management network on port 443. This allows you to upload the Red Hat Enterprise Linux CoreOS (RHCOS) OVA during deployment.
    - An HTTPS firewall rule between the OpenShift Container Platform compute network and vCenter. This connection allows OpenShift Container Platform to communicate with vCenter for provisioning and managing nodes, persistent volume claims (PVCs), and other resources.
- You must have the following information to deploy OpenShift Container Platform:
    - The OpenShift Container Platform cluster name, such as **vmc-prod-1**.
    - The base DNS name, such as **companyname.com**.
    - If not using the default, the pod network CIDR and services network CIDR must be identified, which are set by default to **10.128.0.0/14** and **172.30.0.0/16**, respectively. These CIDRs are used for pod-to-pod and pod-to-service communication and are not accessible externally; however, they must not overlap with existing subnets in your organization.
    - The following vCenter information:

        - vCenter hostname, username, and password
        - Datacenter name, such as **SDDC-Datacenter**
        - Cluster name, such as **Cluster-1**
        - Network name
        - Datastore name, such as **WorkloadDatastore**

NOTE

It is recommended to move your vSphere cluster to the VMC **Compute-ResourcePool** resource pool after your cluster installation is finished.

- A Linux-based host deployed to VMC as a bastion.
    - The bastion host can be Red Hat Enterprise Linux (RHEL) or any another Linux-based host; it must have internet connectivity and the ability to upload an OVA to the ESXi hosts.
    - Download and install the OpenShift CLI tools to the bastion host.
        - The **openshift-install** installation program
        - The OpenShift CLI (**oc**) tool

NOTE

You cannot use the VMware NSX Container Plugin for Kubernetes (NCP), and NSX is not used as the OpenShift SDN. The version of NSX currently available with VMC is incompatible with the version of NCP certified with OpenShift Container Platform.

However, the NSX DHCP service is used for virtual machine IP management with the full-stack automated OpenShift Container Platform deployment and with nodes provisioned, either manually or automatically, by the Machine API integration with vSphere. Additionally, NSX firewall rules are created to enable access with the OpenShift Container Platform cluster and between the bastion host and the VMC vSphere hosts.

22.4.1.1. VMC Sizer tool

VMware Cloud on AWS is built on top of AWS bare metal infrastructure; this is the same bare metal infrastructure which runs AWS native services. When a VMware cloud on AWS software-defined data center (SDDC) is deployed, you consume these physical server nodes and run the VMware ESXi hypervisor in a single tenant fashion. This means the physical infrastructure is not accessible to anyone else using VMC. It is important to consider how many physical hosts you will need to host your virtual infrastructure.

To determine this, VMware provides the VMC on AWS Sizer. With this tool, you can define the resources you intend to host on VMC:

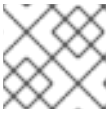
- Types of workloads
- Total number of virtual machines
- Specification information such as:
    - Storage requirements

- Storage requirements
  - vCPUs
  - vRAM
  - Overcommit ratios

With these details, the sizer tool can generate a report, based on VMware best practices, and recommend your cluster configuration and the number of hosts you will need.

22.4.2. vSphere prerequisites

- You reviewed details about the OpenShift Container Platform installation and update processes.
- You read the documentation on selecting a cluster installation method and preparing it for users.
- You provisioned block registry storage. For more information on persistent storage, see Understanding persistent storage.
- If you use a firewall, you configured it to allow the sites that your cluster requires access to.



NOTE

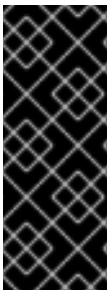
Be sure to also review this site list if you are configuring a proxy.

22.4.3. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.11, you require access to the internet to install your cluster.

You must have internet access to:

- Access OpenShift Cluster Manager Hybrid Cloud Console to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access Quay.io to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.

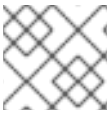


IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

22.4.4. VMware vSphere infrastructure requirements

You must install the OpenShift Container Platform cluster on a VMware vSphere version 7 instance that meets the requirements for the components that you use.



NOTE

OpenShift Container Platform version 4.11 does not support VMware vSphere version 8.0.

You can host the VMware vSphere infrastructure on-premise or on a VMware Cloud Verified provider that meets the requirements outlined in the following table:

Table 22.20. Version requirements for vSphere virtual environments

Virtual environment product	Required version
VM hardware version	15 or later
vSphere ESXi hosts	7
vCenter host	7

IMPORTANT

Installing a cluster on VMware vSphere version 7.0 Update 1 or earlier is now deprecated. These versions are still fully supported, but version 4.11 of OpenShift Container Platform requires vSphere virtual hardware version 15 or later. Hardware version 15 is now the default for vSphere virtual machines in OpenShift Container Platform. To update the hardware version for your vSphere nodes, see the "Updating hardware on nodes running in vSphere" article.

If your vSphere nodes are below hardware version 15 or your VMware vSphere version is earlier than 6.7.3, upgrading from OpenShift Container Platform 4.10 to OpenShift Container Platform 4.11 is not available.

Table 22.21. Minimum supported vSphere version for VMware components

Component	Minimum supported versions	Description
Hypervisor	vSphere 7 with HW version 15	This version is the minimum version that Red Hat Enterprise Linux CoreOS (RHCOS) supports. For more information about supported hardware on the latest version of Red Hat Enterprise Linux (RHEL) that is compatible with RHCOS, see Hardware on the Red Hat Customer Portal.
Storage with in-tree drivers	vSphere 7	This plugin creates vSphere storage by using the in-tree storage drivers for vSphere included in OpenShift Container Platform.

IMPORTANT

You must ensure that the time on your ESXi hosts is synchronized before you install OpenShift Container Platform. See Edit Time Configuration for a Host in the VMware documentation.

22.4.5. Network connectivity requirements

You must configure the network connectivity between machines to allow OpenShift Container Platform cluster components to communicate.

Review the following details about the required network ports.

Table 22.22. Ports used for all-machine to all-machine communications

Protocol	Port	Description
ICMP	N/A	Network reachability tests
TCP	**1936**	Metrics
	9000-**9999**	Host level services, including the node exporter on ports **9100**-**9101** and the Cluster Version Operator on port**9099**.
	10250-**10259**	The default ports that Kubernetes reserves
	10256	openshift-sdn
UDP	**4789**	virtual extensible LAN (VXLAN)
	6081	Geneve
	9000-**9999**	Host level services, including the node exporter on ports **9100**-**9101**.
	500	IPsec IKE packets
	4500	IPsec NAT-T packets
TCP/UDP	**30000**-**32767**	Kubernetes node port
ESP	N/A	IPsec Encapsulating Security Payload (ESP)

Table 22.23. Ports used for all-machine to control plane communications

Protocol	Port	Description
TCP	**6443**	Kubernetes API

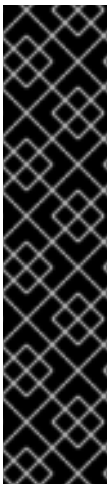
Table 22.24. Ports used for control plane machine to control plane machine communications

Protocol	Port	Description
TCP	**2379-2380**	etcd server and peer ports

22.4.6. VMware vSphere CSI Driver Operator requirements

To install the vSphere CSI Driver Operator, the following requirements must be met:

- VMware vSphere version 7.0 Update 1 or later
- Virtual machines of hardware version 15 or later
- No third-party vSphere CSI driver already installed in the cluster



IMPORTANT

If a third-party vSphere CSI driver is present in the cluster, OpenShift Container Platform does not overwrite it. If you continue with the third-party vSphere CSI driver when upgrading to the next major version of OpenShift Container Platform, the **oc** CLI prompts you with the following message:

> VSphereCSIDriverOperatorCRUpgradeable: VMwareVSphereControllerUpgradeable: found existing unsupported csi.vsphere.vmware.com driver

The previous message informs you that Red Hat does not support the third-party vSphere CSI driver during an OpenShift Container Platform upgrade operation. You can choose to ignore this message and continue with the upgrade operation.

Additional resources

- To remove a third-party CSI driver, see Removing a third-party vSphere CSI Driver .
- To update the hardware version for your vSphere nodes, see Updating hardware on nodes running in vSphere.

22.4.7. vCenter requirements

Before you install an OpenShift Container Platform cluster on your vCenter that uses infrastructure that the installer provisions, you must prepare your environment.

Required vCenter account privileges
To install an OpenShift Container Platform cluster in a vCenter, the installation program requires access to an account with privileges to read and create the required resources. Using an account that has global administrative privileges is the simplest way to access all of the necessary permissions.

If you cannot use an account with global administrative privileges, you must create roles to grant the privileges necessary for OpenShift Container Platform cluster installation. While most of the privileges are always required, some are required only if you plan for the installation program to provision a folder to contain the OpenShift Container Platform cluster on your vCenter instance, which is the default behavior. You must create or amend vSphere roles for the specified objects to grant the required privileges.

An additional role is required if the installation program is to create a vSphere virtual machine folder.

Example 22.7. Roles and privileges required for installation in vSphere API

vSphere object for role	When required	Required privileges in vSphere API
vSphere vCenter	Always	**Cns.Searchable** **InventoryService.Tagging.AttachTag** **InventoryService.Tagging.CreateCategory** **InventoryService.Tagging.CreateTag** **InventoryService.Tagging.DeleteCategory** **InventoryService.Tagging.DeleteTag** **InventoryService.Tagging.EditCategory** **InventoryService.Tagging.EditTag** **Sessions.ValidateSession** **StorageProfile.Update** **StorageProfile.View**
vSphere vCenter Cluster	If VMs will be created in the cluster root	**Host.Config.Storage** **Resource.AssignVMToPool** **VApp.AssignResourcePool** **VApp.Import** **VirtualMachine.Config.AddNewDisk**
vSphere vCenter Resource Pool	If an existing resource pool is provided	**Host.Config.Storage** **Resource.AssignVMToPool** **VApp.AssignResourcePool** **VApp.Import** **VirtualMachine.Config.AddNewDisk**
vSphere Datastore	Always	**Datastore.AllocateSpace** **Datastore.Browse** **Datastore.FileManagement** **InventoryService.Tagging.ObjectAttachable**
vSphere Port Group	Always	**Network.Assign**
Virtual Machine Folder	Always	**InventoryService.Tagging.ObjectAttachable** **Resource.AssignVMToPool** **VApp.Import** **VirtualMachine.Config.Add**

vSphere object for role	When required	Required privileges in vSphere API
		ExistingDisk **VirtualMachine.Config.AddNewDisk** **VirtualMachine.Config.AddRemoveDevice** **VirtualMachine.Config.AdvancedConfig** **VirtualMachine.Config.Annotation** **VirtualMachine.Config.CPUCount** **VirtualMachine.Config.DiskExtend** **VirtualMachine.Config.DiskLease** **VirtualMachine.Config.EditDevice** **VirtualMachine.Config.Memory** **VirtualMachine.Config.RemoveDisk** **VirtualMachine.Config.Rename** **VirtualMachine.Config.ResetGuestInfo** **VirtualMachine.Config.Resource** **VirtualMachine.Config.Settings** **VirtualMachine.Config.UpgradeVirtualHardware** **VirtualMachine.Interact.GuestControl** **VirtualMachine.Interact.PowerOff** **VirtualMachine.Interact.PowerOn** **VirtualMachine.Interact.Reset** **VirtualMachine.Inventory.Create** **VirtualMachine.Inventory.CreateFromExisting** **VirtualMachine.Inventory.Delete** **VirtualMachine.Provisioning.Clone** **VirtualMachine.Provisioning.MarkAsTemplate** **VirtualMachine.Provisioning.DeployTemplate**
vSphere vCenter Datacenter	If the installation program creates the virtual machine folder	**InventoryService.Tagging.ObjectAttachable** **Resource.AssignVMToPool** **VApp.Import**

vSphere object for role	When required	Required privileges in vSphere API
		VirtualMachine.Config.AddExistingDisk VirtualMachine.Config.AddNewDisk VirtualMachine.Config.AddRemoveDevice VirtualMachine.Config.AdvancedConfig VirtualMachine.Config.Annotation VirtualMachine.Config.CPUCount VirtualMachine.Config.DiskExtend VirtualMachine.Config.DiskLease VirtualMachine.Config.EditDevice VirtualMachine.Config.Memory VirtualMachine.Config.RemoveDisk VirtualMachine.Config.Rename VirtualMachine.Config.ResetGuestInfo VirtualMachine.Config.Resource VirtualMachine.Config.Settings VirtualMachine.Config.UpgradeVirtualHardware VirtualMachine.Interact.GuestControl VirtualMachine.Interact.PowerOff VirtualMachine.Interact.PowerOn VirtualMachine.Interact.Reset VirtualMachine.Inventory.Create VirtualMachine.Inventory.CreateFromExisting VirtualMachine.Inventory.Delete VirtualMachine.Provisioning.Clone VirtualMachine.Provisioning.DeployTemplate VirtualMachine.Provisioning.MarkAsTemplate Folder.Create Folder.Delete

Example 22.8. Roles and privileges required for installation in vCenter graphical user interface (GUI)

vSphere object for role	When required	Required privileges in vCenter GUI
vSphere vCenter	Always	**Cns.Searchable "vSphere Tagging"."Assign or Unassign vSphere Tag" "vSphere Tagging"."Create vSphere Tag Category" "vSphere Tagging"."Create vSphere Tag" vSphere Tagging"."Delete vSphere Tag Category" "vSphere Tagging"."Delete vSphere Tag" "vSphere Tagging"."Edit vSphere Tag Category" "vSphere Tagging"."Edit vSphere Tag" Sessions."Validate session" "Profile-driven storage"."Profile-driven storage update" "Profile-driven storage"."Profile-driven storage view"**
vSphere vCenter Cluster	If VMs will be created in the cluster root	**Host.Configuration."Storage partition configuration" Resource."Assign virtual machine to resource pool" VApp."Assign resource pool" VApp.Import "Virtual machine"."Change Configuration"."Add new disk"**
vSphere vCenter Resource Pool	If an existing resource pool is provided	**Host.Configuration."Storage partition configuration" Resource."Assign virtual machine to resource pool" VApp."Assign resource pool" VApp.Import "Virtual machine"."Change Configuration"."Add new disk"**

vSphere object for role	When required	Required privileges in vCenter GUI
vSphere Datastore	Always	**Datastore."Allocate space" Datastore."Browse datastore" Datastore."Low level file operations" "vSphere Tagging"."Assign or Unassign vSphere Tag on Object"**
vSphere Port Group	Always	**Network."Assign network"**
Virtual Machine Folder	Always	**"vSphere Tagging"."Assign or Unassign vSphere Tag on Object" Resource."Assign virtual machine to resource pool" VApp.Import "Virtual machine"."Change Configuration"."Add existing disk" "Virtual machine"."Change Configuration"."Add new disk" "Virtual machine"."Change Configuration"."Add or remove device" "Virtual machine"."Change Configuration"."Advanced configuration" "Virtual machine"."Change Configuration"."Set annotation" "Virtual machine"."Change Configuration"."Change CPU count" "Virtual machine"."Change Configuration"."Extend virtual disk" "Virtual machine"."Change Configuration"."Acquire disk lease" "Virtual machine"."Change Configuration"."Modify device settings" "Virtual machine"."Change Configuration"."Change Memory" "Virtual machine"."Change Configuration"."Remove**

vSphere object for role	When required	Required privileges in vCenter GUI
		disk" "Virtual machine"."Change Configuration".Rename "Virtual machine"."Change Configuration"."Reset guest information" "Virtual machine"."Change Configuration"."Change resource" "Virtual machine"."Change Configuration"."Change Settings" "Virtual machine"."Change Configuration"."Upgrade virtual machine compatibility" "Virtual machine".Interaction."Guest operating system management by VIX API" "Virtual machine".Interaction."Power off" "Virtual machine".Interaction."Power on" "Virtual machine".Interaction.Reset "Virtual machine"."Edit Inventory"."Create new" "Virtual machine"."Edit Inventory"."Create from existing" "Virtual machine"."Edit Inventory"."Remove" "Virtual machine".Provisioning."Clone virtual machine" "Virtual machine".Provisioning."Mark as template" "Virtual machine".Provisioning."Deploy template"
vSphere vCenter Datacenter	If the installation program creates the virtual machine folder	**"vSphere Tagging"."Assign or Unassign vSphere Tag on Object" Resource."Assign virtual machine to resource pool" VApp.Import "Virtual machine"."Change Configuration"."Add existing disk" "Virtual machine"."Change Configuration"."Add new**

vSphere object for role	When required	Required privileges in vCenter GUI
		"Virtual machine"."Change Configuration"."Add or remove device" "Virtual machine"."Change Configuration"."Advanced configuration" "Virtual machine"."Change Configuration"."Set annotation" "Virtual machine"."Change Configuration"."Change CPU count" "Virtual machine"."Change Configuration"."Extend virtual disk" "Virtual machine"."Change Configuration"."Acquire disk lease" "Virtual machine"."Change Configuration"."Modify device settings" "Virtual machine"."Change Configuration"."Change Memory" "Virtual machine"."Change Configuration"."Remove disk" "Virtual machine"."Change Configuration".Rename "Virtual machine"."Change Configuration"."Reset guest information" "Virtual machine"."Change Configuration"."Change resource" "Virtual machine"."Change Configuration"."Change Settings" "Virtual machine"."Change Configuration"."Upgrade virtual machine compatibility" "Virtual machine".Interaction."Guest operating system management by VIX API" "Virtual machine".Interaction."Power off" "Virtual machine".Interaction."Power on" "Virtual machine".Interaction.Reset "Virtual machine"."Edit

vSphere object for role	When required	Required privileges in vCenter GUI
		Inventory"."Create new" "Virtual machine"."Edit Inventory"."Create from existing" "Virtual machine"."Edit Inventory"."Remove" "Virtual machine".Provisioning."Clone virtual machine" "Virtual machine".Provisioning."Deploy template" "Virtual machine".Provisioning."Mark as template" Folder."Create folder" Folder."Delete folder"

Additionally, the user requires some **ReadOnly** permissions, and some of the roles require permission to propogate the permissions to child objects. These settings vary depending on whether or not you install the cluster into an existing folder.

Example 22.9. Required permissions and propagation settings

vSphere object	When required	Propagate to children	Permissions required
vSphere vCenter	Always	False	Listed required privileges
vSphere vCenter Datacenter	Existing folder	False	**ReadOnly** permission
	Installation program creates the folder	True	Listed required privileges
vSphere vCenter Cluster	Existing resource pool	False	**ReadOnly** permission
	VMs in cluster root	True	Listed required privileges
vSphere vCenter Datastore	Always	False	Listed required privileges
vSphere Switch	Always	False	**ReadOnly** permission
vSphere Port Group	Always	False	Listed required privileges
vSphere vCenter Virtual Machine Folder	Existing folder	True	Listed required privileges

vSphere object	When required	Propagate to children	Permissions required
vSphere vCenter Resource Pool	Existing resource pool	True	Listed required privileges

For more information about creating an account with only the required privileges, see vSphere Permissions and User Management Tasks in the vSphere documentation.

Using OpenShift Container Platform with vMotion
If you intend on using vMotion in your vSphere environment, consider the following before installing a OpenShift Container Platform cluster.

- OpenShift Container Platform generally supports compute-only vMotion, where *generally* implies that you meet all VMware best practices for vMotion.
  To help ensure the uptime of your compute and control plane nodes, ensure that you follow the VMware best practices for vMotion, and use VMware anti-affinity rules to improve the availability of OpenShift Container Platform during maintenance or hardware issues.

  For more information about vMotion and anti-affinity rules, see the VMware vSphere documentation for vMotion networking requirements and VM anti-affinity rules.

- Using Storage vMotion can cause issues and is not supported. If you are using vSphere volumes in your pods, migrating a VM across datastores, either manually or through Storage vMotion, causes invalid references within OpenShift Container Platform persistent volume (PV) objects that can result in data loss.

- OpenShift Container Platform does not support selective migration of VMDKs across datastores, using datastore clusters for VM provisioning or for dynamic or static provisioning of PVs, or using a datastore that is part of a datastore cluster for dynamic or static provisioning of PVs.

Cluster resources
When you deploy an OpenShift Container Platform cluster that uses installer-provisioned infrastructure, the installation program must be able to create several resources in your vCenter instance.

A standard OpenShift Container Platform installation creates the following vCenter resources:

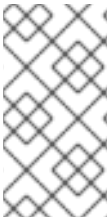
- 1 Folder
- 1 Tag category
- 1 Tag
- Virtual machines:
  - 1 template
  - 1 temporary bootstrap node
  - 3 control plane nodes
  - 3 compute machines

Although these resources use 856 GB of storage, the bootstrap node is destroyed during the cluster installation process. A minimum of 800 GB of storage is required to use a standard cluster.

If you deploy more compute machines, the OpenShift Container Platform cluster will use more storage.

Cluster limits
Available resources vary between clusters. The number of possible clusters within a vCenter is limited primarily by available storage space and any limitations on the number of required resources. Be sure to consider both limitations to the vCenter resources that the cluster creates and the resources that you require to deploy a cluster, such as IP addresses and networks.

Networking requirements
You must use the Dynamic Host Configuration Protocol (DHCP) for the network and ensure that the DHCP server is configured to provide persistent IP addresses to the cluster machines. In the DHCP lease, you must configure the DHCP to use the default gateway. All nodes must be in the same VLAN. You cannot scale the cluster using a second VLAN as a Day 2 operation. Additionally, you must create the following networking resources before you install the OpenShift Container Platform cluster:



NOTE

It is recommended that each OpenShift Container Platform node in the cluster must have access to a Network Time Protocol (NTP) server that is discoverable via DHCP. Installation is possible without an NTP server. However, asynchronous server clocks will cause errors, which NTP server prevents.

Required IP Addresses
An installer-provisioned vSphere installation requires two static IP addresses:

- The **API** address is used to access the cluster API.
- The **Ingress** address is used for cluster ingress traffic.

You must provide these IP addresses to the installation program when you install the OpenShift Container Platform cluster.

DNS records
You must create DNS records for two static IP addresses in the appropriate DNS server for the vCenter instance that hosts your OpenShift Container Platform cluster. In each record, **<cluster_name>** is the cluster name and **<base_domain>** is the cluster base domain that you specify when you install the cluster. A complete DNS record takes the form: **<component>.<cluster_name>.<base_domain>.**.

Table 22.25. Required DNS records

Component	Record	Description
API VIP	**api.<cluster_name>.<base_domain>.**	This DNS A/AAAA or CNAME record must point to the load balancer for the control plane machines. This record must be resolvable by both clients external to the cluster and from all the nodes within the cluster.

Component	Record	Description
Ingress VIP	***.apps.<cluster_name>.<base_domain>.**	A wildcard DNS A/AAAA or CNAME record that points to the load balancer that targets the machines that run the Ingress router pods, which are the worker nodes by default. This record must be resolvable by both clients external to the cluster and from all the nodes within the cluster.

22.4.8. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the **~/.ssh/authorized_keys** list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The **./openshift-install gather** command also requires the SSH public key to be in place on the cluster nodes.

IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.

NOTE

You must use a local key, not one that you configured with platform-specific approaches such as AWS key pairs.

Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N '' -f <path>/<file_name> 1
```

1 Specify the path and file name, such as **~/.ssh/id_ed25519**, of the new SSH key. If you have an existing key pair, ensure your public key is in the your **~/.ssh** directory.

NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS validated or Modules In Process cryptographic libraries on the **x86_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the ~/**.ssh/id_ed25519.pub** public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the **./openshift-install gather** command.

NOTE

On some distributions, default SSH private key identities such as ~/**.ssh/id_rsa** and ~/**.ssh/id_dsa** are managed automatically.

a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

Example output

```
Agent pid 31874
```

NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> (1)
```

(1) Specify the path and file name for your SSH private key, such as ~/**.ssh/id_ed25519**

Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

Next steps

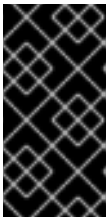
- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

22.4.9. Obtaining the installation program

Before you install OpenShift Container Platform, download the installation file on a local computer.

Prerequisites

- You have a machine that runs Linux, for example Red Hat Enterprise Linux 8, with 500 MB of local disk space.

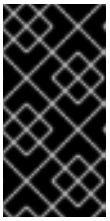


IMPORTANT

If you attempt to run the installation program on macOS, a known issue related to the **golang** compiler causes the installation of the OpenShift Container Platform cluster to fail. For more information about this issue, see the section named "Known Issues" in the *OpenShift Container Platform 4.11 release notes* document.

Procedure

1. Access the Infrastructure Provider page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program that corresponds with your host operating system and architecture, and place the file in the directory where you will store the installation configuration files.



IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.

IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation pull secret from the Red Hat OpenShift Cluster Manager . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

22.4.10. Adding vCenter root CA certificates to your system trust

Because the installation program requires access to your vCenter's API, you must add your vCenter's trusted root CA certificates to your system trust before you install an OpenShift Container Platform cluster.

Procedure

1. From the vCenter home page, download the vCenter's root CA certificates. Click **Download trusted root CA certificates** in the vSphere Web Services SDK section. The **<vCenter>/certs/download.zip** file downloads.

2. Extract the compressed file that contains the vCenter root CA certificates. The contents of the compressed file resemble the following file structure:

```
certs
├── lin
│   ├── 108f4d17.0
│   ├── 108f4d17.r1
│   ├── 7e757f6a.0
│   ├── 8e4f8471.0
│   └── 8e4f8471.r0
├── mac
│   ├── 108f4d17.0
│   ├── 108f4d17.r1
│   ├── 7e757f6a.0
│   ├── 8e4f8471.0
│   └── 8e4f8471.r0
└── win
    ├── 108f4d17.0.crt
    ├── 108f4d17.r1.crl
    ├── 7e757f6a.0.crt
    ├── 8e4f8471.0.crt
    └── 8e4f8471.r0.crl

3 directories, 15 files
```

3. Add the files for your operating system to the system trust. For example, on a Fedora operating system, run the following command:

```
# cp certs/lin/* /etc/pki/ca-trust/source/anchors
```

4. Update your system trust. For example, on a Fedora operating system, run the following command:

```
# update-ca-trust extract
```

22.4.11. Creating the installation configuration file

You can customize the OpenShift Container Platform cluster you install on VMware vSphere.

Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.
- Obtain service principal permissions at the subscription level.

Procedure

1. Create the **install-config.yaml** file.
   a. Change to the directory that contains the installation program and run the following command:

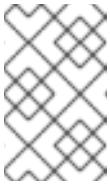
```
$ ./openshift-install create install-config --dir <installation_directory> 1
```

   1 For **<installation_directory>**, specify the directory name to store the files that the installation program creates.

   When specifying the directory:

   - Verify that the directory has the **execute** permission. This permission is required to run Terraform binaries under the installation directory.
   - Use an empty directory. Some installation assets, such as bootstrap X.509 certificates, have short expiration intervals, therefore you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

   b. At the prompts, provide the configuration details for your cloud:
      i. Optional: Select an SSH key to use to access your cluster machines.



NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

      ii. Select **vsphere** as the platform to target.
      iii. Specify the name of your vCenter instance.
      iv. Specify the user name and password for the vCenter account that has the required permissions to create the cluster.
      The installation program connects to your vCenter instance.
      v. Select the datacenter in your vCenter instance to connect to.
      vi. Select the default vCenter datastore to use.
      vii. Select the vCenter cluster to install the OpenShift Container Platform cluster in. The installation program uses the root resource pool of the vSphere cluster as the default resource pool.

viii. Select the network in the vCenter instance that contains the virtual IP addresses and DNS records that you configured.

ix. Enter the virtual IP address that you configured for control plane API access.

x. Enter the virtual IP address that you configured for cluster ingress.

xi. Enter the base domain. This base domain must be the same one that you used in the DNS records that you configured.

xii. Enter a descriptive name for your cluster. The cluster name you enter must match the cluster name you specified when configuring the DNS records.

xiii. Paste the pull secret from the Red Hat OpenShift Cluster Manager .

2. Modify the **install-config.yaml** file. You can find more information about the available parameters in the "Installation configuration parameters" section.

3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.

IMPORTANT

The **install-config.yaml** file is consumed during the installation process. If you want to reuse the file, you must back it up now.

22.4.11.1. Installation configuration parameters

Before you deploy an OpenShift Container Platform cluster, you provide parameter values to describe your account on the cloud platform that hosts your cluster and optionally customize your cluster's platform. When you create the **install-config.yaml** installation configuration file, you provide values for the required parameters through the command line. If you customize your cluster, you can modify the **install-config.yaml** file to provide more details about the platform.

NOTE

After installation, you cannot modify these parameters in the **install-config.yaml** file.

22.4.11.1.1. Required configuration parameters

Required installation configuration parameters are described in the following table:

Table 22.26. Required parameters

Parameter	Description	Values
apiVersion	The API version for the **install-config.yaml** content. The current version is **v1**. The installer may also support older API versions.	String

Parameter	Description	Values
baseDomain	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the **baseDomain** and **metadata.name** parameter values that uses the **<metadata.name>.<baseDomain>** format.	A fully-qualified domain or subdomain name, such as **example.com**.
metadata	Kubernetes resource **ObjectMeta**, from which only the **name** parameter is consumed.	Object
metadata.name	The name of the cluster. DNS records for the cluster are all subdomains of **{{.metadata.name}}.{{.baseDomain}}**.	String of lowercase letters and hyphens (**-**), such as **dev**.
platform	The configuration for the specific platform upon which to perform the installation: **alibabacloud**, **aws**, **baremetal**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**. For additional information about **platform.<platform>** parameters, consult the table for your specific platform that follows.	Object
pullSecret	Get a pull secret from the Red Hat OpenShift Cluster Manager to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	<pre>{ "auths":{ "cloud.openshift.com":{ "auth":"b3Blb=", "email":"you@example.com" }, "quay.io":{ "auth":"b3Blb=", "email":"you@example.com" } } }</pre>

22.4.11.1.2. Network configuration parameters

You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

Only IPv4 addresses are supported.

NOTE

Globalnet is not supported with Red Hat OpenShift Data Foundation disaster recovery solutions. For regional disaster recovery scenarios, ensure that you use a nonoverlapping range of private IP addresses for the cluster and service networks in each cluster.

Table 22.27. Network parameters

Parameter	Description	Values
networking	The configuration for the cluster network.	Object  NOTE You cannot modify parameters specified by the **networking** object after installation.
networking.networkType	The cluster network provider Container Network Interface (CNI) cluster network provider to install.	Either **OpenShiftSDN** or **OVNKubernetes**. **OpenShiftSDN** is a CNI provider for all-Linux networks. **OVNKubernetes** is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is **OpenShiftSDN**.
networking.clusterNetwork	The IP address blocks for pods. The default value is **10.128.0.0/14** with a host prefix of **/23**. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: `networking:` `  clusterNetwork:` `  - cidr: 10.128.0.0/14` `  hostPrefix: 23`
networking.clusterNetwork.cidr	Required if you use **networking.clusterNetwork**. An IP address block. An IPv4 network.	An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between **0** and **32**.

Parameter	Description	Values
networking.clusterNetwork.hostPrefix	The subnet prefix length to assign to each individual node. For example, if **hostPrefix** is set to **23** then each node is assigned a /**23** subnet out of the given **cidr**. A **hostPrefix** value of **23** provides 510 (2^(32 - 23) - 2) pod IP addresses.	A subnet prefix. The default value is **23**.
networking.serviceNetwork	The IP address block for services. The default value is **172.30.0.0/16**. The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.	An array with an IP address block in CIDR format. For example: networking: serviceNetwork: - 172.30.0.0/16
networking.machineNetwork	The IP address blocks for machines. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: networking: machineNetwork: - cidr: 10.0.0.0/16
networking.machineNetwork.cidr	Required if you use **networking.machineNetwork**. An IP address block. The default value is **10.0.0.0/16** for all platforms other than libvirt. For libvirt, the default value is **192.168.126.0/24**.	An IP network block in CIDR notation. For example, **10.0.0.0/16**. **NOTE** Set the **networking.machineNetwork** to match the CIDR that the preferred NIC resides in.

22.4.11.1.3. Optional configuration parameters

Optional installation configuration parameters are described in the following table:

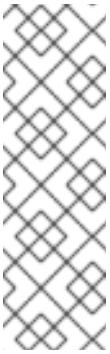
Table 22.28. Optional parameters

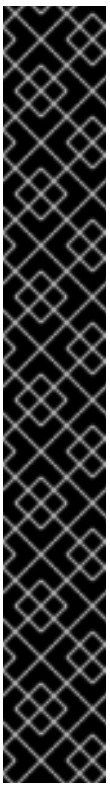
Parameter	Description	Values
additionalTrustBundle	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String

Parameter	Description	Values
capabilities	Controls the installation of optional core cluster components. You can reduce the footprint of your OpenShift Container Platform cluster by disabling optional components.	String array
capabilities.baselineCapabilitySet	Selects an initial set of optional capabilities to enable. Valid values are **None**, **v4.11** and **vCurrent**. **v4.11** enables the **baremetal** Operator, the **marketplace** Operator, and the **openshift-samples** content. **vCurrent** installs the recommended set of capabilities for the current version of OpenShift Container Platform. The default value is **vCurrent**.	String
capabilities.additionalEnabledCapabilities	Extends the set of optional capabilities beyond what you specify in **baselineCapabilitySet**. Valid values are **baremetal**, **marketplace** and **openshift-samples**. You may specify multiple capabilities in this parameter.	String array
cgroupsV2	Enables Linux control groups version 2 (cgroups v2) on specific nodes in your cluster. The OpenShift Container Platform process for enabling cgroups v2 disables all cgroup version 1 controllers and hierarchies. The OpenShift Container Platform cgroups version 2 feature is in Developer Preview and is not supported by Red Hat at this time.	**true**
compute	The configuration for the machines that comprise the compute nodes.	Array of **MachinePool** objects.
compute.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** (the default).	String

Parameter	Description	Values
compute.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  IMPORTANT If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
compute.name	Required if you use **compute**. The name of the machine pool.	**worker**
compute.platform	Required if you use **compute**. Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the **controlPlane.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
compute.replicas	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to **2**. The default value is **3**.
controlPlane	The configuration for the machines that comprise the control plane.	Array of **MachinePool** objects.
controlPlane.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** (the default).	String

Parameter	Description	Values
controlPlane.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  IMPORTANT If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
controlPlane.name	Required if you use **controlPlane**. The name of the machine pool.	**master**
controlPlane.platform	Required if you use **controlPlane**. Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the **compute.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
controlPlane.replicas	The number of control plane machines to provision.	The only supported value is **3**, which is the default value.

Parameter	Description	Values
credentialsMode	The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported.  **NOTE** Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the *Cloud Credential Operator* entry in the *Cluster Operators reference* content.  **NOTE** If your AWS account has service control policies (SCP) enabled, you must configure the **credentialsMode** parameter to **Mint**, **Passthrough** or **Manual**.	**Mint**, **Passthrough**, **Manual** or an empty string (**""**).

Parameter	Description	Values
fips	Enable or disable FIPS mode. The default is **false** (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.  **IMPORTANT** To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.  **NOTE** If you are using Azure File storage, you cannot enable FIPS mode.	**false** or **true**
imageContentSources	Sources and repositories for the release-image content.	Array of objects. Includes a **source** and, optionally, **mirrors**, as described in the following rows of this table.
imageContentSources.source	Required if you use **imageContentSources**. Specify the repository that users refer to, for example, in image pull specifications.	String

Parameter	Description	Values
imageContentSources.mirrors	Specify one or more repositories that may also contain the same images.	Array of strings
publish	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	**Internal** or **External**. The default value is **External**. Setting this field to **Internal** is not supported on non-cloud platforms and IBM Cloud VPC.  IMPORTANT If the value of the field is set to **Internal**, the cluster will become non-functional. For more information, refer to BZ#1953035.
sshKey	The SSH key to authenticate access to your cluster machines.  NOTE For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.	For example, **sshKey: ssh-ed25519 AAAA..**.

22.4.11.1.4. Additional VMware vSphere configuration parameters

Additional VMware vSphere configuration parameters are described in the following table:

Table 22.29. Additional VMware vSphere cluster parameters

Parameter	Description	Values
platform: vsphere vCenter	The fully-qualified hostname or IP address of the vCenter server.	String
platform: vsphere username	The user name to use to connect to the vCenter instance with. This user must have at least the roles and privileges that are required for static or dynamic persistent volume provisioning in vSphere.	String
platform: vsphere password	The password for the vCenter user name.	String
platform: vsphere datacenter	The name of the datacenter to use in the vCenter instance.	String
platform: vsphere defaultDatastore	The name of the default datastore to use for provisioning volumes.	String
platform: vsphere folder	Optional. The absolute path of an existing folder where the installation program creates the virtual machines. If you do not provide this value, the installation program creates a folder that is named with the infrastructure ID in the datacenter virtual machine folder.	String, for example, **/<datacenter_name>/vm/<folder_name>/<subfolder_name>**.
platform: vsphere resourcePool	Optional. The absolute path of an existing resource pool where the installer creates the virtual machines. If you do not specify a value, resources are installed in the root of the cluster **/<datacenter_name>/host/<cluster_name>/Resources**.	String, for example, **/<datacenter_name>/host/<cluster_name>/Resources/<resource_pool_name>/<optional_nested_resource_pool_name>**.
platform: vsphere network	The network in the vCenter instance that contains the virtual IP addresses and DNS records that you configured.	String

Parameter	Description	Values
platform: vsphere cluster	The vCenter cluster to install the OpenShift Container Platform cluster in.	String
platform: vsphere apiVIP	The virtual IP (VIP) address that you configured for control plane API access.	An IP address, for example **128.0.0.1**.
platform: vsphere ingressVIP	The virtual IP (VIP) address that you configured for cluster ingress.	An IP address, for example **128.0.0.1**.
platform: vsphere diskType	Optional. The disk provisioning method. This value defaults to the vSphere default storage policy if not set.	Valid values are **thin**, **thick**, or **eagerZeroedThick**.

22.4.11.1.5. Optional VMware vSphere machine pool configuration parameters

Optional VMware vSphere machine pool configuration parameters are described in the following table:

Table 22.30. Optional VMware vSphere machine pool parameters

Parameter	Description	Values
platform: vsphere clusterOSImage	The location from which the installer downloads the RHCOS image. You must set this parameter to perform an installation in a restricted network.	An HTTP or HTTPS URL, optionally with a SHA-256 checksum. For example, **https://mirror.openshift.com/images/rhcos-<version>-vmware.<architecture>.ova**.
platform vsphere osDisk diskSizeGB	The size of the disk in gigabytes.	Integer

Parameter	Description	Values
platform vsphere cpus	The total number of virtual processor cores to assign a virtual machine. The value of **platform.vsphere.cpus** must be a multiple of **platform.vsphere.coresPerSocket** value.	Integer
platform vsphere coresPerSocket	The number of cores per socket in a virtual machine. The number of virtual sockets on the virtual machine is **platform.vsphere.cpus**/**platform.vsphere.coresPerSocket**. The default value for control plane nodes and worker nodes is **4** and **2**, respectively.	Integer
platform vsphere memoryMB	The size of a virtual machine's memory in megabytes.	Integer

22.4.11.2. Sample install-config.yaml file for an installer-provisioned VMware vSphere cluster

You can customize the install-config.yaml file to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.

```
apiVersion: v1
baseDomain: example.com (1)
compute: (2)
  name: worker
  replicas: 3
  platform:
    vsphere: (3)
      cpus: 2
      coresPerSocket: 2
      memoryMB: 8192
      osDisk:
        diskSizeGB: 120
controlPlane: (4)
  name: master
  replicas: 3
  platform:
    vsphere: (5)
      cpus: 4
      coresPerSocket: 2
      memoryMB: 16384
      osDisk:
        diskSizeGB: 120
metadata:
```

```
  name: cluster 6
networking:
  clusterNetwork:
  - cidr: 10.128.0.0/14
    hostPrefix: 23
  machineNetwork:
  - cidr: 10.0.0.0/16
  networkType: OpenShiftSDN
  serviceNetwork:
  - 172.30.0.0/16
platform:
  vsphere:
    vcenter: your.vcenter.server
    username: username
    password: password
    datacenter: datacenter
    defaultDatastore: datastore
    folder: folder
    resourcePool: resource_pool 7
    diskType: thin 8
    network: VM_Network
    cluster: vsphere_cluster_name 9
    apiVIP: api_vip
    ingressVIP: ingress_vip
fips: false
pullSecret: '{"auths": ...}'
sshKey: 'ssh-ed25519 AAAA...'
```

1 The base domain of the cluster. All DNS records must be sub-domains of this base and include the cluster name.

2 4 The **controlPlane** section is a single mapping, but the **compute** section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, **-**, and the first line of the **controlPlane** section must not. Only one control plane pool is used.

3 5 Optional: Provide additional configuration for the machine pool parameters for the compute and control plane machines.

6 The cluster name that you specified in your DNS records.

7 Optional: Provide an existing resource pool for machine creation. If you do not specify a value, the installation program uses the root resource pool of the vSphere cluster.

8 The vSphere disk provisioning method.

9 The vSphere cluster to install the OpenShift Container Platform cluster in.

22.4.11.3. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.

NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

Procedure

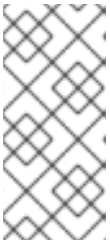
1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
```

1. A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
2. A proxy URL to use for creating HTTPS connections outside the cluster.
3. A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use ***** to bypass the proxy for all destinations. You must include vCenter's IP address and the IP range that you use for its machines.
4. If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace that contains one or more additional CA certificates that are required for proxying HTTPS connections. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges these contents with the Red Hat Enterprise Linux CoreOS (RHCOS) trust bundle, and this config map is referenced in the **trustedCA** field of the **Proxy** object. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.

NOTE

The installation program does not support the proxy **readinessEndpoints** field.



NOTE

If the installer times out, restart and then complete the deployment by using the **wait-for** command of the installer. For example:

```
$ ./openshift-install wait-for install-complete --log-level debug
```

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.

NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

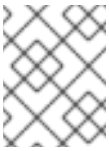
22.4.12. Network configuration phases

There are two phases prior to OpenShift Container Platform installation where you can customize the network configuration.

Phase 1

You can customize the following network-related fields in the **install-config.yaml** file before you create the manifest files:

- **networking.networkType**
- **networking.clusterNetwork**
- **networking.serviceNetwork**
- **networking.machineNetwork**
  For more information on these fields, refer to *Installation configuration parameters*.



NOTE

Set the **networking.machineNetwork** to match the CIDR that the preferred NIC resides in.

IMPORTANT

The CIDR range **172.17.0.0/16** is reserved by libVirt. You cannot use this range or any range that overlaps with this range for any networks in your cluster.

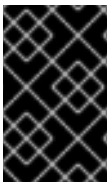
Phase 2

After creating the manifest files by running **openshift-install create manifests**, you can define a customized Cluster Network Operator manifest with only the fields you want to modify. You can use the manifest to specify advanced network configuration.

You cannot override the values specified in phase 1 in the **install-config.yaml** file during phase 2. However, you can further customize the cluster network provider during phase 2.

22.4.13. Specifying advanced network configuration

You can use advanced network configuration for your cluster network provider to integrate your cluster into your existing network environment. You can specify advanced network configuration only before you install the cluster.



IMPORTANT

Customizing your network configuration by modifying the OpenShift Container Platform manifest files created by the installation program is not supported. Applying a manifest file that you create, as in the following procedure, is supported.

Prerequisites

- You have created the **install-config.yaml** file and completed any modifications to it.

Procedure

1. Change to the directory that contains the installation program and create the manifests:

```
$ ./openshift-install create manifests --dir <installation_directory> 1
```

1 **<installation_directory>** specifies the name of the directory that contains the **install-config.yaml** file for your cluster.

2. Create a stub manifest file for the advanced network configuration that is named **cluster-network-03-config.yml** in the **<installation_directory>/manifests/** directory:

```
apiVersion: operator.openshift.io/v1
kind: Network
metadata:
  name: cluster
spec:
```

3. Specify the advanced network configuration for your cluster in the **cluster-network-03-config.yml** file, such as in the following examples:

Specify a different VXLAN port for the OpenShift SDN network provider

```
apiVersion: operator.openshift.io/v1
kind: Network
metadata:
  name: cluster
spec:
```

```
  defaultNetwork:
    openshiftSDNConfig:
      vxlanPort: 4800
```

Enable IPsec for the OVN-Kubernetes network provider

```
apiVersion: operator.openshift.io/v1
kind: Network
metadata:
  name: cluster
spec:
  defaultNetwork:
    ovnKubernetesConfig:
      ipsecConfig: {}
```

4. Optional: Back up the **manifests/cluster-network-03-config.yml** file. The installation program consumes the **manifests/** directory when you create the Ignition config files.

22.4.14. Cluster Network Operator configuration

The configuration for the cluster network is specified as part of the Cluster Network Operator (CNO) configuration and stored in a custom resource (CR) object that is named **cluster**. The CR specifies the fields for the **Network** API in the **operator.openshift.io** API group.

The CNO configuration inherits the following fields during cluster installation from the **Network** API in the **Network.config.openshift.io** API group and these fields cannot be changed:

clusterNetwork

IP address pools from which pod IP addresses are allocated.

serviceNetwork

IP address pool for services.

defaultNetwork.type

Cluster network provider, such as OpenShift SDN or OVN-Kubernetes.

You can specify the cluster network provider configuration for your cluster by setting the fields for the **defaultNetwork** object in the CNO object named **cluster**.

22.4.14.1. Cluster Network Operator configuration object

The fields for the Cluster Network Operator (CNO) are described in the following table:

Table 22.31. Cluster Network Operator configuration object

Field	Type	Description
metadata.name	**string**	The name of the CNO object. This name is always **cluster**.

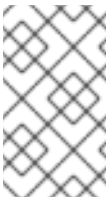
Field	Type	Description
spec.clusterNetwork	**array**	A list specifying the blocks of IP addresses from which pod IP addresses are allocated and the subnet prefix length assigned to each individual node in the cluster. For example: spec: clusterNetwork: - cidr: 10.128.0.0/19 hostPrefix: 23 - cidr: 10.128.32.0/19 hostPrefix: 23 You can customize this field only in the **install-config.yaml** file before you create the manifests. The value is read-only in the manifest file.
spec.serviceNetwork	**array**	A block of IP addresses for services. The OpenShift SDN and OVN-Kubernetes Container Network Interface (CNI) network providers support only a single IP address block for the service network. For example: spec: serviceNetwork: - 172.30.0.0/14 You can customize this field only in the **install-config.yaml** file before you create the manifests. The value is read-only in the manifest file.
spec.defaultNetwork	**object**	Configures the Container Network Interface (CNI) cluster network provider for the cluster network.
spec.kubeProxyConfig	**object**	The fields for this object specify the kube-proxy configuration. If you are using the OVN-Kubernetes cluster network provider, the kube-proxy configuration has no effect.

defaultNetwork object configuration

The values for the **defaultNetwork** object are defined in the following table:

Table 22.32. **defaultNetwork** object

Field	Type	Description

Field	Type	Description
type	**string**	Either **OpenShiftSDN** or **OVNKubernetes**. The cluster network provider is selected during installation. This value cannot be changed after cluster installation.  **NOTE** OpenShift Container Platform uses the OpenShift SDN Container Network Interface (CNI) cluster network provider by default.
openshiftSDNConfig	**object**	This object is only valid for the OpenShift SDN cluster network provider.
ovnKubernetesConfig	**object**	This object is only valid for the OVN-Kubernetes cluster network provider.

Configuration for the OpenShift SDN CNI cluster network provider
The following table describes the configuration fields for the OpenShift SDN Container Network Interface (CNI) cluster network provider.

Table 22.33. **openshiftSDNConfig** object

Field	Type	Description
mode	**string**	Configures the network isolation mode for OpenShift SDN. The default value is **NetworkPolicy**. The values **Multitenant** and **Subnet** are available for backwards compatibility with OpenShift Container Platform 3.x but are not recommended. This value cannot be changed after cluster installation.

Field	Type	Description
mtu	**integer**	The maximum transmission unit (MTU) for the VXLAN overlay network. This is detected automatically based on the MTU of the primary network interface. You do not normally need to override the detected MTU. If the auto-detected value is not what you expect it to be, confirm that the MTU on the primary network interface on your nodes is correct. You cannot use this option to change the MTU value of the primary network interface on the nodes. If your cluster requires different MTU values for different nodes, you must set this value to **50** less than the lowest MTU value in your cluster. For example, if some nodes in your cluster have an MTU of **9001**, and some have an MTU of**1500**, you must set this value to **1450**. This value cannot be changed after cluster installation.
vxlanPort	**integer**	The port to use for all VXLAN packets. The default value is **4789**. This value cannot be changed after cluster installation. If you are running in a virtualized environment with existing nodes that are part of another VXLAN network, then you might be required to change this. For example, when running an OpenShift SDN overlay on top of VMware NSX-T, you must select an alternate port for the VXLAN, because both SDNs use the same default VXLAN port number. On Amazon Web Services (AWS), you can select an alternate port for the VXLAN between port **9000** and port **9999**.

Example OpenShift SDN configuration

```
defaultNetwork:
  type: OpenShiftSDN
  openshiftSDNConfig:
    mode: NetworkPolicy
    mtu: 1450
    vxlanPort: 4789
```

Configuration for the OVN-Kubernetes CNI cluster network provider

The following table describes the configuration fields for the OVN-Kubernetes CNI cluster network provider.

Table 22.34. **ovnKubernetesConfig** object

Field	Type	Description

Field	Type	Description
mtu	**integer**	The maximum transmission unit (MTU) for the Geneve (Generic Network Virtualization Encapsulation) overlay network. This is detected automatically based on the MTU of the primary network interface. You do not normally need to override the detected MTU. If the auto-detected value is not what you expect it to be, confirm that the MTU on the primary network interface on your nodes is correct. You cannot use this option to change the MTU value of the primary network interface on the nodes. If your cluster requires different MTU values for different nodes, you must set this value to **100** less than the lowest MTU value in your cluster. For example, if some nodes in your cluster have an MTU of **9001**, and some have an MTU of**1500**, you must set this value to **1400**.
genevePort	**integer**	The port to use for all Geneve packets. The default value is **6081**. This value cannot be changed after cluster installation.
ipsecConfig	**object**	Specify an empty object to enable IPsec encryption.
policyAuditConfig	**object**	Specify a configuration object for customizing network policy audit logging. If unset, the defaults audit log settings are used.
gatewayConfig	**object**	Optional: Specify a configuration object for customizing how egress traffic is sent to the node gateway.  NOTE While migrating egress traffic, you can expect some disruption to workloads and service traffic until the Cluster Network Operator (CNO) successfully rolls out the changes.

Table 22.35. **policyAuditConfig** object

Field	Type	Description
rateLimit	integer	The maximum number of messages to generate every second per node. The default value is **20** messages per second.
maxFileSize	integer	The maximum size for the audit log in bytes. The default value is **50000000** or 50 MB.

Field	Type	Description
destination	string	One of the following additional audit log targets: **libc** The libc **syslog()** function of the journald process on the host. **udp:<host>:<port>** A syslog server. Replace **<host>:<port>** with the host and port of the syslog server. **unix:<file>** A Unix Domain Socket file specified by **<file>**. **null** Do not send the audit logs to any additional target.
syslogFacility	string	The syslog facility, such as **kern**, as defined by RFC5424. The default value is **local0**.

Table 22.36. **gatewayConfig** object

Field	Type	Description
routingViaHost	**boolean**	Set this field to **true** to send egress traffic from pods to the host networking stack. For highly-specialized installations and applications that rely on manually configured routes in the kernel routing table, you might want to route egress traffic to the host networking stack. By default, egress traffic is processed in OVN to exit the cluster and is not affected by specialized routes in the kernel routing table. The default value is **false**. This field has an interaction with the Open vSwitch hardware offloading feature. If you set this field to **true**, you do not receive the performance benefits of the offloading because egress traffic is processed by the host networking stack.

Example OVN-Kubernetes configuration with IPSec enabled

```
defaultNetwork:
  type: OVNKubernetes
  ovnKubernetesConfig:
    mtu: 1400
    genevePort: 6081
    ipsecConfig: {}
```

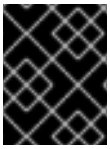
kubeProxyConfig object configuration
The values for the **kubeProxyConfig** object are defined in the following table:

Table 22.37. **kubeProxyConfig** object

Field	Type	Description
iptablesSyncPeriod	**string**	The refresh period for **iptables** rules. The default value is **30s**. Valid suffixes include **s**, **m**, and **h** and are described in the Go **time** package documentation.  **NOTE** Because of performance improvements introduced in OpenShift Container Platform 4.3 and greater, adjusting the **iptablesSyncPeriod** parameter is no longer necessary.
proxyArguments.iptables-min-sync-period	**array**	The minimum duration before refreshing **iptables** rules. This field ensures that the refresh does not happen too frequently. Valid suffixes include **s**, **m**, and **h** and are described in the Go **time** package. The default value is: `kubeProxyConfig:` `  proxyArguments:` `  iptables-min-sync-period:` `  - 0s`

22.4.15. Deploying the cluster

You can install OpenShift Container Platform on a compatible cloud platform.



IMPORTANT

You can run the **create cluster** command of the installation program only once, during initial installation.

Prerequisites

- Configure an account with the cloud platform that hosts your cluster.
- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.

Procedure

- Change to the directory that contains the installation program and initialize the cluster deployment:

```
$ ./openshift-install create cluster --dir <installation_directory> \ 1
    --log-level=info 2
```

1. For **<installation_directory>**, specify the location of your customized **./install-config.yaml** file.
2. To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

IMPORTANT

Use the **openshift-install** command from the bastion hosted in the VMC environment.

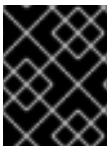
NOTE

If the cloud provider account that you configured on your host does not have sufficient permissions to deploy the cluster, the installation process stops, and the missing permissions are displayed.

Verification

When the cluster deployment completes successfully:

- The terminal displays directions for accessing your cluster, including a link to the web console and credentials for the **kubeadmin** user.
- Credential information also outputs to **<installation_directory>/.openshift_install.log**.



IMPORTANT

Do not delete the installation program or the files that the installation program creates. Both are required to delete the cluster.

Example output

```
...
INFO Install complete!
INFO To access the cluster as the system:admin user when using 'oc', run 'export
KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
INFO Access the OpenShift web-console here: https://console-openshift-
console.apps.mycluster.example.com
INFO Login to the console with user: "kubeadmin", and password: "password"
INFO Time elapsed: 36m22s
```

IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

22.4.16. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.

IMPORTANT

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.11. Download and install the new version of **oc**.

Installing the OpenShift CLI on Linux

You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the architecture in the **Product Variant** drop-down menu.
3. Select the appropriate version in the **Version** drop-down menu.
4. Click **Download Now** next to the **OpenShift v4.11 Linux Client** entry and save the file.
5. Unpack the archive:

```
$ tar xvf <file>
```

6. Place the **oc** binary in a directory that is on your **PATH**.
   To check your **PATH**, execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.
   To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
C:\> oc <command>
```

Installing the OpenShift CLI on macOS

You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 macOS Client** entry and save the file.

NOTE

For macOS arm64, choose the **OpenShift v4.11 macOS arm64 Client** entry.

4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your PATH.
   To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

22.4.17. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

Example output

```
system:admin
```

22.4.18. Creating registry storage

After you install the cluster, you must create storage for the registry Operator.

22.4.18.1. Image registry removed during installation

On platforms that do not provide shareable object storage, the OpenShift Image Registry Operator bootstraps itself as **Removed**. This allows **openshift-installer** to complete installations on these platform types.

After installation, you must edit the Image Registry Operator configuration to switch the **managementState** from **Removed** to **Managed**.

22.4.18.2. Image registry storage configuration

The Image Registry Operator is not initially available for platforms that do not provide default storage. After installation, you must configure your registry to use storage so that the Registry Operator is made available.

Instructions are shown for configuring a persistent volume, which is required for production clusters. Where applicable, instructions are shown for configuring an empty directory as the storage location, which is available for only non-production clusters.

Additional instructions are provided for allowing the image registry to use block storage types by using the **Recreate** rollout strategy during upgrades.

22.4.18.2.1. Configuring registry storage for VMware vSphere

As a cluster administrator, following installation you must configure your registry to use storage.

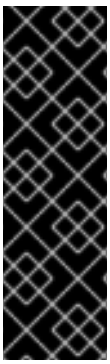
Prerequisites

- Cluster administrator permissions.
- A cluster on VMware vSphere.
- Persistent storage provisioned for your cluster, such as Red Hat OpenShift Data Foundation.

IMPORTANT

OpenShift Container Platform supports **ReadWriteOnce** access for image registry storage when you have only one replica. **ReadWriteOnce** access also requires that the registry uses the **Recreate** rollout strategy. To deploy an image registry that supports high availability with two or more replicas, **ReadWriteMany** access is required.

- Must have "100Gi" capacity.



IMPORTANT

Testing shows issues with using the NFS server on RHEL as storage backend for core services. This includes the OpenShift Container Registry and Quay, Prometheus for monitoring storage, and Elasticsearch for logging storage. Therefore, using RHEL NFS to back PVs used by core services is not recommended.

Other NFS implementations on the marketplace might not have these issues. Contact the individual NFS implementation vendor for more information on any testing that was possibly completed against these OpenShift Container Platform core components.

Procedure

1. To configure your registry to use storage, change the **spec.storage.pvc** in the **configs.imageregistry/cluster** resource.

NOTE

When you use shared storage, review your security settings to prevent outside access.

2. Verify that you do not have a registry pod:

```
$ oc get pod -n openshift-image-registry -l docker-registry=default
```

Example output

```
No resourses found in openshift-image-registry namespace
```

NOTE

If you do have a registry pod in your output, you do not need to continue with this procedure.

3. Check the registry configuration:

```
$ oc edit configs.imageregistry.operator.openshift.io
```

Example output

```
storage:
  pvc:
    claim: 1
```

1 Leave the **claim** field blank to allow the automatic creation of an **image-registry-storage** persistent volume claim (PVC). The PVC is generated based on the default storage class. However, be aware that the default storage class might provide ReadWriteOnce (RWO) volumes, such as a RADOS Block Device (RBD), which can cause issues when you replicate to more than one replica.

4. Check the **clusteroperator** status:

```
$ oc get clusteroperator image-registry
```

Example output

```
NAME             VERSION                             AVAILABLE   PROGRESSING   DEGRADED
SINCE   MESSAGE
image-registry   4.7                                 True        False         False      6h50m
```

22.4.18.2.2. Configuring block registry storage for VMware vSphere

To allow the image registry to use block storage types such as vSphere Virtual Machine Disk (VMDK) during upgrades as a cluster administrator, you can use the **Recreate** rollout strategy.

IMPORTANT

Block storage volumes are supported but not recommended for use with image registry on production clusters. An installation where the registry is configured on block storage is not highly available because the registry cannot have more than one replica.

Procedure

1. Enter the following command to set the image registry storage as a block storage type, patch the registry so that it uses the **Recreate** rollout strategy, and runs with only **1** replica:

```
$ oc patch config.imageregistry.operator.openshift.io/cluster --type=merge -p '{"spec":
{"rolloutStrategy":"Recreate","replicas":1}}'
```

2. Provision the PV for the block storage device, and create a PVC for that volume. The requested block volume uses the ReadWriteOnce (RWO) access mode.

   a. Create a **pvc.yaml** file with the following contents to define a VMware vSphere **PersistentVolumeClaim** object:

```
kind: PersistentVolumeClaim
apiVersion: v1
metadata:
  name: image-registry-storage 1
  namespace: openshift-image-registry 2
spec:
  accessModes:
  - ReadWriteOnce 3
  resources:
    requests:
      storage: 100Gi 4
```

   1. A unique name that represents the **PersistentVolumeClaim** object.
   2. The namespace for the **PersistentVolumeClaim** object, which is **openshift-image-registry**.
   3. The access mode of the persistent volume claim. With **ReadWriteOnce**, the volume can be mounted with read and write permissions by a single node.
   4. The size of the persistent volume claim.

   b. Enter the following command to create the **PersistentVolumeClaim** object from the file:

```
$ oc create -f pvc.yaml -n openshift-image-registry
```

3. Enter the following command to edit the registry configuration so that it references the correct PVC:

```
$ oc edit config.imageregistry.operator.openshift.io -o yaml
```

Example output

```
storage:
  pvc:
    claim: 1
```

1. By creating a custom PVC, you can leave the **claim** field blank for the default automatic creation of an **image-registry-storage** PVC.

For instructions about configuring registry storage so that it references the correct PVC, see Configuring the registry for vSphere.

22.4.19. Backing up VMware vSphere volumes

OpenShift Container Platform provisions new volumes as independent persistent disks to freely attach and detach the volume on any node in the cluster. As a consequence, it is not possible to back up volumes that use snapshots, or to restore volumes from snapshots. See Snapshot Limitations for more information.

Procedure

To create a backup of persistent volumes:

1. Stop the application that is using the persistent volume.
2. Clone the persistent volume.
3. Restart the application.
4. Create a backup of the cloned volume.
5. Delete the cloned volume.

22.4.20. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.11, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to OpenShift Cluster Manager Hybrid Cloud Console.

After you confirm that your OpenShift Cluster Manager Hybrid Cloud Console inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, use subscription watch to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

Additional resources

- See About remote health monitoring for more information about the Telemetry service

22.4.21. Configuring an external load balancer

You can configure an OpenShift Container Platform cluster to use an external load balancer in place of the default load balancer.

IMPORTANT

Configuring an external load balancer depends on your vendor's load balancer.

The information and examples in this section are for guideline purposes only. Consult the vendor documentation for more specific information about the vendor's load balancer.

Red Hat supports the following services for an external load balancer:

- Ingress Controller
- OpenShift API
- OpenShift MachineConfig API

You can choose whether you want to configure one or all of these services for an external load balancer. Configuring only the Ingress Controller service is a common configuration option. To better understand each service, view the following diagrams:

Figure 22.7. Example network workflow that shows an Ingress Controller operating in an OpenShift Container Platform environment

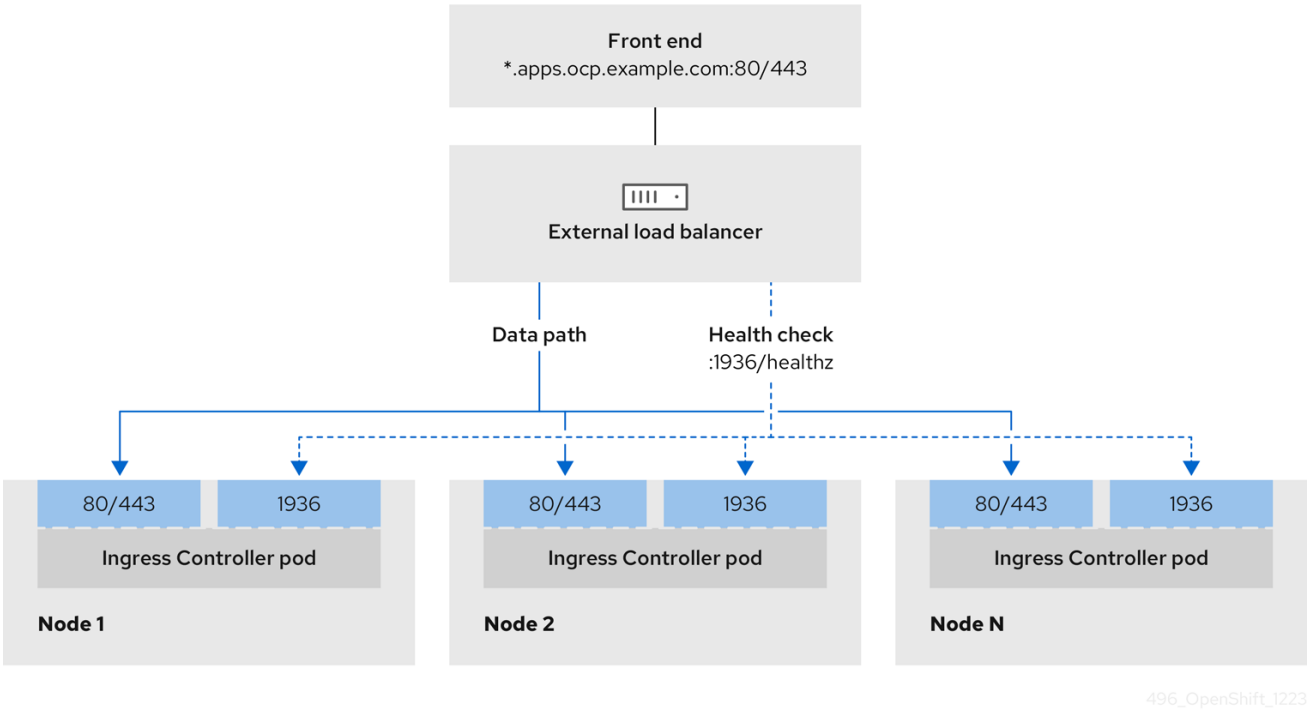


Figure 22.8. Example network workflow that shows an OpenShift API operating in an OpenShift Container Platform environment

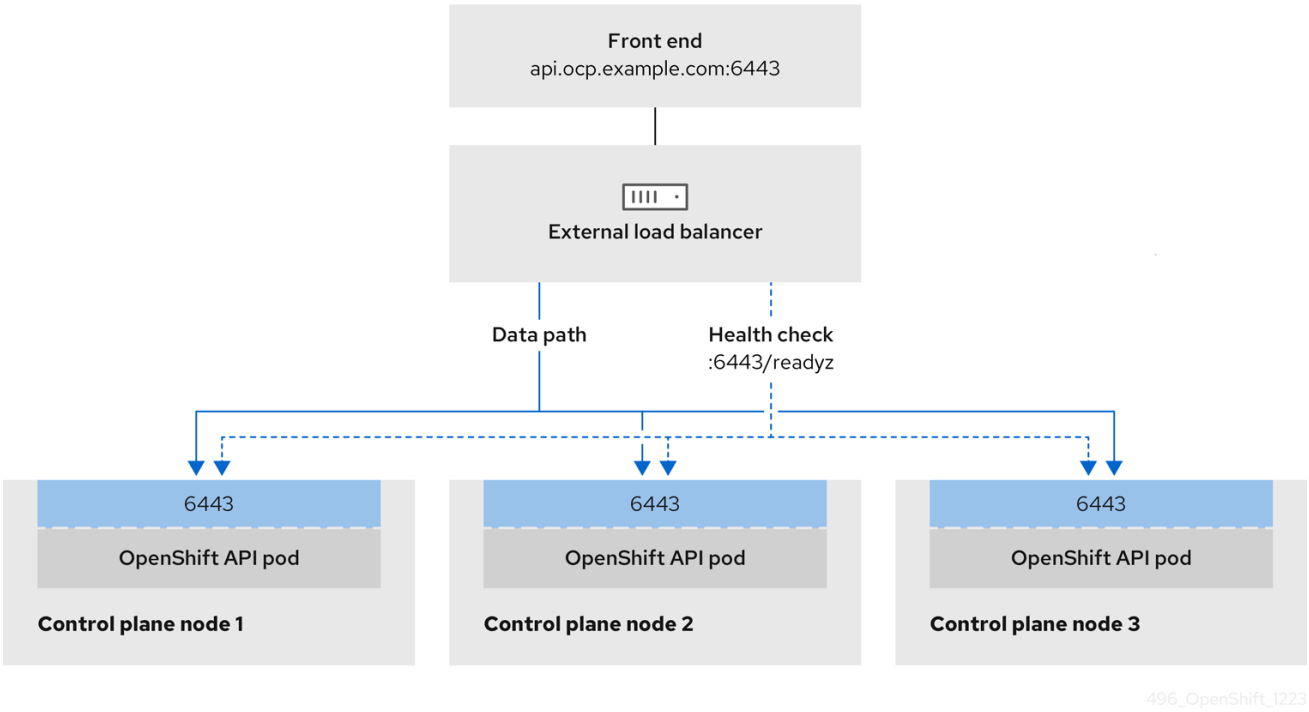
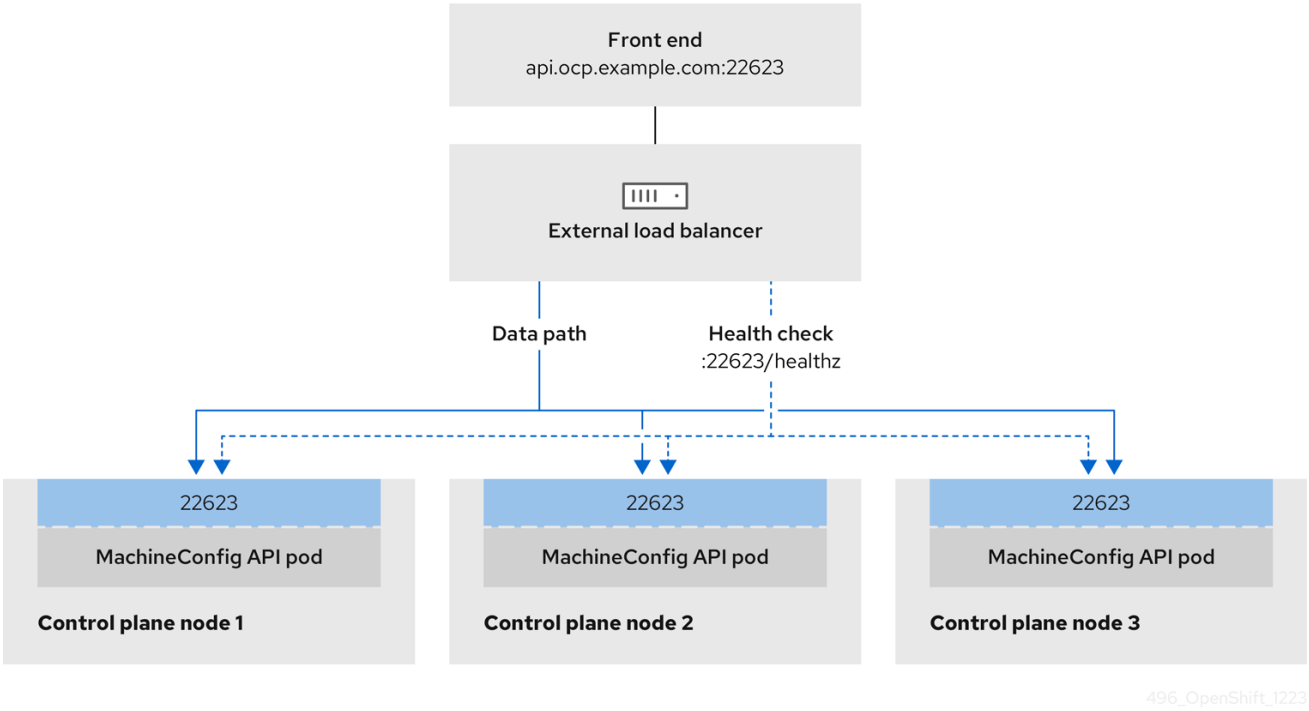


Figure 22.9. Example network workflow that shows an OpenShift MachineConfig API operating in an OpenShift Container Platform environment



Considerations

- For a front-end IP address, you can use the same IP address for the front-end IP address, the Ingress Controller's load balancer, and API load balancer. Check the vendor's documentation for this capability.
- For a back-end IP address, ensure that an IP address for an OpenShift Container Platform control plane node does not change during the lifetime of the external load balancer. You can achieve this by completing one of the following actions:
  - Assign a static IP address to each control plane node.
  - Configure each node to receive the same IP address from the DHCP every time the node requests a DHCP lease. Depending on the vendor, the DHCP lease might be in the form of an IP reservation or a static DHCP assignment.
- Manually define each node that runs the Ingress Controller in the external load balancer for the Ingress Controller back-end service. For example, if the Ingress Controller moves to an undefined node, a connection outage can occur.

OpenShift API prerequisites

- You defined a front-end IP address.
- TCP ports 6443 and 22623 are exposed on the front-end IP address of your load balancer. Check the following items:
  - Port 6443 provides access to the OpenShift API service.
  - Port 22623 can provide ignition startup configurations to nodes.

- The front-end IP address and port 6443 are reachable by all users of your system with a location external to your OpenShift Container Platform cluster.
- The front-end IP address and port 22623 are reachable only by OpenShift Container Platform nodes.
- The load balancer backend can communicate with OpenShift Container Platform control plane nodes on port 6443 and 22623.

Ingress Controller prerequisites

- You defined a front-end IP address.
- TCP ports 443 and 80 are exposed on the front-end IP address of your load balancer.
- The front-end IP address, port 80 and port 443 are be reachable by all users of your system with a location external to your OpenShift Container Platform cluster.
- The front-end IP address, port 80 and port 443 are reachable to all nodes that operate in your OpenShift Container Platform cluster.
- The load balancer backend can communicate with OpenShift Container Platform nodes that run the Ingress Controller on ports 80, 443, and 1936.

Prerequisite for health check URL specifications

You can configure most load balancers by setting health check URLs that determine if a service is available or unavailable. OpenShift Container Platform provides these health checks for the OpenShift API, Machine Configuration API, and Ingress Controller backend services.

The following examples demonstrate health check specifications for the previously listed backend services:

Example of a Kubernetes API health check specification

```
Path: HTTPS:6443/readyz
Healthy threshold: 2
Unhealthy threshold: 2
Timeout: 10
Interval: 10
```

Example of a Machine Config API health check specification

```
Path: HTTPS:22623/healthz
Healthy threshold: 2
Unhealthy threshold: 2
Timeout: 10
Interval: 10
```

Example of an Ingress Controller health check specification

```
Path: HTTP:1936/healthz/ready
Healthy threshold: 2
Unhealthy threshold: 2
```

```
Timeout: 5
Interval: 10
```

Procedure

1. Configure the HAProxy Ingress Controller, so that you can enable access to the cluster from your load balancer on ports 6443, 443, and 80:

   Example HAProxy configuration

```
#...
listen my-cluster-api-6443
    bind 192.168.1.100:6443
    mode tcp
    balance roundrobin
  option httpchk
  http-check connect
  http-check send meth GET uri /readyz
  http-check expect status 200
    server my-cluster-master-2 192.168.1.101:6443 check inter 10s rise 2 fall 2
    server my-cluster-master-0 192.168.1.102:6443 check inter 10s rise 2 fall 2
    server my-cluster-master-1 192.168.1.103:6443 check inter 10s rise 2 fall 2

listen my-cluster-machine-config-api-22623
    bind 192.168.1.1000.0.0.0:22623
    mode tcp
    balance roundrobin
  option httpchk
  http-check connect
  http-check send meth GET uri /healthz
  http-check expect status 200
    server my-cluster-master-2 192.0168.21.2101:22623 check inter 10s rise 2 fall 2
    server my-cluster-master-0 192.168.1.1020.2.3:22623 check inter 10s rise 2 fall 2
    server my-cluster-master-1 192.168.1.1030.2.1:22623 check inter 10s rise 2 fall 2

listen my-cluster-apps-443
        bind 192.168.1.100:443
        mode tcp
        balance roundrobin
    option httpchk
    http-check connect
    http-check send meth GET uri /healthz/ready
    http-check expect status 200
        server my-cluster-worker-0 192.168.1.111:443 check port 1936 inter 10s rise 2 fall 2
        server my-cluster-worker-1 192.168.1.112:443 check port 1936 inter 10s rise 2 fall 2
        server my-cluster-worker-2 192.168.1.113:443 check port 1936 inter 10s rise 2 fall 2

listen my-cluster-apps-80
        bind 192.168.1.100:80
        mode tcp
        balance roundrobin
    option httpchk
    http-check connect
    http-check send meth GET uri /healthz/ready
    http-check expect status 200
```

```
        server my-cluster-worker-0 192.168.1.111:80 check port 1936 inter 10s rise 2 fall 2
        server my-cluster-worker-1 192.168.1.112:80 check port 1936 inter 10s rise 2 fall 2
        server my-cluster-worker-2 192.168.1.113:80 check port 1936 inter 10s rise 2 fall 2
# ...
```

2. Use the **curl** CLI command to verify that the external load balancer and its resources are operational:

   a. Verify that the cluster machine configuration API is accessible to the Kubernetes API server resource, by running the following command and observing the response:

   ```
   $ curl https://<loadbalancer_ip_address>:6443/version --insecure
   ```

   If the configuration is correct, you receive a JSON object in response:

   ```
   {
     "major": "1",
     "minor": "11+",
     "gitVersion": "v1.11.0+ad103ed",
     "gitCommit": "ad103ed",
     "gitTreeState": "clean",
     "buildDate": "2019-01-09T06:44:10Z",
     "goVersion": "go1.10.3",
     "compiler": "gc",
     "platform": "linux/amd64"
   }
   ```

   b. Verify that the cluster machine configuration API is accessible to the Machine config server resource, by running the following command and observing the output:

   ```
   $ curl -v https://<loadbalancer_ip_address>:22623/healthz --insecure
   ```

   If the configuration is correct, the output from the command shows the following response:

   ```
   HTTP/1.1 200 OK
   Content-Length: 0
   ```

   c. Verify that the controller is accessible to the Ingress Controller resource on port 80, by running the following command and observing the output:

   ```
   $ curl -I -L -H "Host: console-openshift-console.apps.<cluster_name>.<base_domain>"
   http://<load_balancer_front_end_IP_address>
   ```

   If the configuration is correct, the output from the command shows the following response:

   ```
   HTTP/1.1 302 Found
   content-length: 0
   location: https://console-openshift-console.apps.ocp4.private.opequon.net/
   cache-control: no-cache
   ```

   d. Verify that the controller is accessible to the Ingress Controller resource on port 443, by running the following command and observing the output:

```
$ curl -I -L --insecure --resolve console-openshift-console.apps.<cluster_name>.
<base_domain>:443:<Load Balancer Front End IP Address> https://console-openshift-
console.apps.<cluster_name>.<base_domain>
```

If the configuration is correct, the output from the command shows the following response:

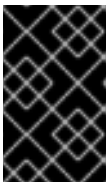
```
HTTP/1.1 200 OK
referrer-policy: strict-origin-when-cross-origin
set-cookie: csrf-
token=UlYWOyQ62LWjw2h003xtYSKlh1a0Py2hhctw0WmV2YEdhJjFyQwWcGBsja261dG
LgaYO0nxzVErhiXt6QepA7g==; Path=/; Secure; SameSite=Lax
x-content-type-options: nosniff
x-dns-prefetch-control: off
x-frame-options: DENY
x-xss-protection: 1; mode=block
date: Wed, 04 Oct 2023 16:29:38 GMT
content-type: text/html; charset=utf-8
set-cookie:
1e2670d92730b515ce3a1bb65da45062=1bf5e9573c9a2760c964ed1659cc1673; path=/;
HttpOnly; Secure; SameSite=None
cache-control: private
```

3. Configure the DNS records for your cluster to target the front-end IP addresses of the external load balancer. You must update records to your DNS server for the cluster API and applications over the load balancer.

Examples of modified DNS records

```
<load_balancer_ip_address>  A  api.<cluster_name>.<base_domain>
A record pointing to Load Balancer Front End
```

```
<load_balancer_ip_address>  A apps.<cluster_name>.<base_domain>
A record pointing to Load Balancer Front End
```



IMPORTANT

DNS propagation might take some time for each DNS record to become available. Ensure that each DNS record propagates before validating each record.

4. Use the **curl** CLI command to verify that the external load balancer and DNS record configuration are operational:

   a. Verify that you can access the cluster API, by running the following command and observing the output:

```
$ curl https://api.<cluster_name>.<base_domain>:6443/version --insecure
```

   If the configuration is correct, you receive a JSON object in response:

```
{
  "major": "1",
  "minor": "11+",
```

```
  "gitVersion": "v1.11.0+ad103ed",
  "gitCommit": "ad103ed",
  "gitTreeState": "clean",
  "buildDate": "2019-01-09T06:44:10Z",
  "goVersion": "go1.10.3",
  "compiler": "gc",
  "platform": "linux/amd64"
  }
```

b. Verify that you can access the cluster machine configuration, by running the following command and observing the output:

```
$ curl -v https://api.<cluster_name>.<base_domain>:22623/healthz --insecure
```

If the configuration is correct, the output from the command shows the following response:

```
HTTP/1.1 200 OK
Content-Length: 0
```

c. Verify that you can access each cluster application on port, by running the following command and observing the output:

```
$ curl http://console-openshift-console.apps.<cluster_name>.<base_domain> -I -L --
insecure
```

If the configuration is correct, the output from the command shows the following response:

```
HTTP/1.1 302 Found
content-length: 0
location: https://console-openshift-console.apps.<cluster-name>.<base domain>/
cache-control: no-cacheHTTP/1.1 200 OK
referrer-policy: strict-origin-when-cross-origin
set-cookie: csrf-
token=39HoZgztDnzjJkq/JuLJMeoKNXlfiVv2YgZc09c3TBOBU4Nl6kDXaJH1LdicNhN1UsQ
Wzon4Dor9GWGfopaTEQ==; Path=/; Secure
x-content-type-options: nosniff
x-dns-prefetch-control: off
x-frame-options: DENY
x-xss-protection: 1; mode=block
date: Tue, 17 Nov 2020 08:42:10 GMT
content-type: text/html; charset=utf-8
set-cookie:
1e2670d92730b515ce3a1bb65da45062=9b714eb87e93cf34853e87a92d6894be; path=/;
HttpOnly; Secure; SameSite=None
cache-control: private
```

d. Verify that you can access each cluster application on port 443, by running the following command and observing the output:

```
$ curl https://console-openshift-console.apps.<cluster_name>.<base_domain> -I -L --
insecure
```

If the configuration is correct, the output from the command shows the following response:

```
HTTP/1.1 200 OK
referrer-policy: strict-origin-when-cross-origin
set-cookie: csrf-
token=UlYWOyQ62LWjw2h003xtYSKlh1a0Py2hhctw0WmV2YEdhJjFyQwWcGBsja261dG
LgaYO0nxzVErhiXt6QepA7g==; Path=/; Secure; SameSite=Lax
x-content-type-options: nosniff
x-dns-prefetch-control: off
x-frame-options: DENY
x-xss-protection: 1; mode=block
date: Wed, 04 Oct 2023 16:29:38 GMT
content-type: text/html; charset=utf-8
set-cookie:
1e2670d92730b515ce3a1bb65da45062=1bf5e9573c9a2760c964ed1659cc1673; path=/;
HttpOnly; Secure; SameSite=None
cache-control: private
```

22.4.22. Next steps

- Customize your cluster.
- If necessary, you can opt out of remote health reporting .
- Set up your registry and configure registry storage .
- Optional: View the events from the vSphere Problem Detector Operator to determine if the cluster has permission or storage configuration issues.

22.5. INSTALLING A CLUSTER ON VMC IN A RESTRICTED NETWORK

In OpenShift Container Platform version 4.11, you can install a cluster on VMware vSphere infrastructure in a restricted network by deploying it to VMware Cloud (VMC) on AWS.

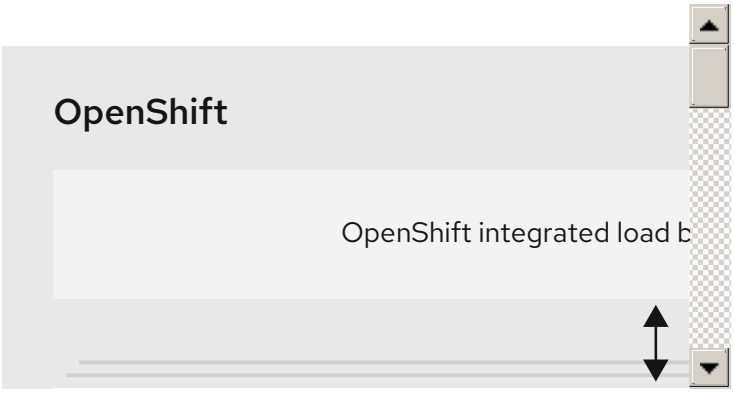
Once you configure your VMC environment for OpenShift Container Platform deployment, you use the OpenShift Container Platform installation program from the bastion management host, co-located in the VMC environment. The installation program and control plane automates the process of deploying and managing the resources needed for the OpenShift Container Platform cluster.

NOTE

OpenShift Container Platform supports deploying a cluster to a single VMware vCenter only. Deploying a cluster with machines/machine sets on multiple vCenters is not supported.

22.5.1. Setting up VMC for vSphere

You can install OpenShift Container Platform on VMware Cloud (VMC) on AWS hosted vSphere clusters to enable applications to be deployed and managed both on-premise and off-premise, across the hybrid cloud.



You must configure several options in your VMC environment prior to installing OpenShift Container Platform on VMware vSphere. Ensure your VMC environment has the following prerequisites:

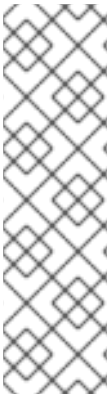
- Create a non-exclusive, DHCP-enabled, NSX-T network segment and subnet. Other virtual machines (VMs) can be hosted on the subnet, but at least eight IP addresses must be available for the OpenShift Container Platform deployment.
- Allocate two IP addresses, outside the DHCP range, and configure them with reverse DNS records.
    - A DNS record for **api.<cluster_name>.<base_domain>** pointing to the allocated IP address.
    - A DNS record for ***.apps.<cluster_name>.<base_domain>** pointing to the allocated IP address.
- Configure the following firewall rules:
    - An ANY:ANY firewall rule between the installation host and the software-defined data center (SDDC) management network on port 443. This allows you to upload the Red Hat Enterprise Linux CoreOS (RHCOS) OVA during deployment.
    - An HTTPS firewall rule between the OpenShift Container Platform compute network and vCenter. This connection allows OpenShift Container Platform to communicate with vCenter for provisioning and managing nodes, persistent volume claims (PVCs), and other resources.
- You must have the following information to deploy OpenShift Container Platform:
    - The OpenShift Container Platform cluster name, such as **vmc-prod-1**.
    - The base DNS name, such as **companyname.com**.
    - If not using the default, the pod network CIDR and services network CIDR must be identified, which are set by default to **10.128.0.0/14** and **172.30.0.0/16**, respectively. These CIDRs are used for pod-to-pod and pod-to-service communication and are not accessible externally; however, they must not overlap with existing subnets in your organization.
    - The following vCenter information:
        - vCenter hostname, username, and password
        - Datacenter name, such as **SDDC-Datacenter**
        - Cluster name, such as **Cluster-1**

- Network name
- Datastore name, such as **WorkloadDatastore**

NOTE

It is recommended to move your vSphere cluster to the VMC **Compute-ResourcePool** resource pool after your cluster installation is finished.

- A Linux-based host deployed to VMC as a bastion.
  - The bastion host can be Red Hat Enterprise Linux (RHEL) or any another Linux-based host; it must have internet connectivity and the ability to upload an OVA to the ESXi hosts.
  - Download and install the OpenShift CLI tools to the bastion host.
    - The **openshift-install** installation program
    - The OpenShift CLI (**oc**) tool



NOTE

You cannot use the VMware NSX Container Plugin for Kubernetes (NCP), and NSX is not used as the OpenShift SDN. The version of NSX currently available with VMC is incompatible with the version of NCP certified with OpenShift Container Platform.

However, the NSX DHCP service is used for virtual machine IP management with the full-stack automated OpenShift Container Platform deployment and with nodes provisioned, either manually or automatically, by the Machine API integration with vSphere. Additionally, NSX firewall rules are created to enable access with the OpenShift Container Platform cluster and between the bastion host and the VMC vSphere hosts.

22.5.1.1. VMC Sizer tool

VMware Cloud on AWS is built on top of AWS bare metal infrastructure; this is the same bare metal infrastructure which runs AWS native services. When a VMware cloud on AWS software-defined data center (SDDC) is deployed, you consume these physical server nodes and run the VMware ESXi hypervisor in a single tenant fashion. This means the physical infrastructure is not accessible to anyone else using VMC. It is important to consider how many physical hosts you will need to host your virtual infrastructure.

To determine this, VMware provides the VMC on AWS Sizer. With this tool, you can define the resources you intend to host on VMC:

- Types of workloads
- Total number of virtual machines
- Specification information such as:
  - Storage requirements
  - vCPUs
  - vRAM

- Overcommit ratios

With these details, the sizer tool can generate a report, based on VMware best practices, and recommend your cluster configuration and the number of hosts you will need.

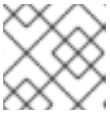
22.5.2. vSphere prerequisites

- You reviewed details about the OpenShift Container Platform installation and update processes.
- You read the documentation on selecting a cluster installation method and preparing it for users.
- You created a registry on your mirror host and obtained the **imageContentSources** data for your version of OpenShift Container Platform.

IMPORTANT

Because the installation media is on the mirror host, you can use that computer to complete all installation steps.

- You provisioned block registry storage. For more information on persistent storage, see Understanding persistent storage.
- If you use a firewall and plan to use the Telemetry service, you configured the firewall to allow the sites that your cluster requires access to.



NOTE

If you are configuring a proxy, be sure to also review this site list.

22.5.3. About installations in restricted networks

In OpenShift Container Platform 4.11, you can perform an installation that does not require an active connection to the internet to obtain software components. Restricted network installations can be completed using installer-provisioned infrastructure or user-provisioned infrastructure, depending on the cloud platform to which you are installing the cluster.

If you choose to perform a restricted network installation on a cloud platform, you still require access to its cloud APIs. Some cloud functions, like Amazon Web Service's Route 53 DNS and IAM services, require internet access. Depending on your network, you might require less internet access for an installation on bare metal hardware or on VMware vSphere.

To complete a restricted network installation, you must create a registry that mirrors the contents of the OpenShift image registry and contains the installation media. You can create this registry on a mirror host, which can access both the internet and your closed network, or by using other methods that meet your restrictions.

22.5.3.1. Additional limits

Clusters in restricted networks have the following additional limitations and restrictions:

- The **ClusterVersion** status includes an **Unable to retrieve available updates** error.

- By default, you cannot use the contents of the Developer Catalog because you cannot access the required image stream tags.

22.5.4. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.11, you require access to the internet to obtain the images that are necessary to install your cluster.

You must have internet access to:

- Access OpenShift Cluster Manager Hybrid Cloud Console to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access Quay.io to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.

IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

22.5.5. VMware vSphere infrastructure requirements

You must install the OpenShift Container Platform cluster on a VMware vSphere version 7 instance that meets the requirements for the components that you use.

NOTE

OpenShift Container Platform version 4.11 does not support VMware vSphere version 8.0.

You can host the VMware vSphere infrastructure on-premise or on a VMware Cloud Verified provider that meets the requirements outlined in the following table:

Table 22.38. Version requirements for vSphere virtual environments

Virtual environment product	Required version
VM hardware version	15 or later
vSphere ESXi hosts	7
vCenter host	7

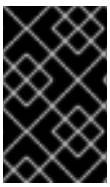
IMPORTANT

Installing a cluster on VMware vSphere version 7.0 Update 1 or earlier is now deprecated. These versions are still fully supported, but version 4.11 of OpenShift Container Platform requires vSphere virtual hardware version 15 or later. Hardware version 15 is now the default for vSphere virtual machines in OpenShift Container Platform. To update the hardware version for your vSphere nodes, see the "Updating hardware on nodes running in vSphere" article.

If your vSphere nodes are below hardware version 15 or your VMware vSphere version is earlier than 6.7.3, upgrading from OpenShift Container Platform 4.10 to OpenShift Container Platform 4.11 is not available.

Table 22.39. Minimum supported vSphere version for VMware components

Component	Minimum supported versions	Description
Hypervisor	vSphere 7 with HW version 15	This version is the minimum version that Red Hat Enterprise Linux CoreOS (RHCOS) supports. For more information about supported hardware on the latest version of Red Hat Enterprise Linux (RHEL) that is compatible with RHCOS, see Hardware on the Red Hat Customer Portal.
Storage with in-tree drivers	vSphere 7	This plugin creates vSphere storage by using the in-tree storage drivers for vSphere included in OpenShift Container Platform.



IMPORTANT

You must ensure that the time on your ESXi hosts is synchronized before you install OpenShift Container Platform. See Edit Time Configuration for a Host in the VMware documentation.

22.5.6. Network connectivity requirements

You must configure the network connectivity between machines to allow OpenShift Container Platform cluster components to communicate.

Review the following details about the required network ports.

Table 22.40. Ports used for all-machine to all-machine communications

Protocol	Port	Description
ICMP	N/A	Network reachability tests

Protocol	Port	Description
TCP	**1936**	Metrics
	9000-9999	Host level services, including the node exporter on ports **9100-9101** and the Cluster Version Operator on port**9099**.
	10250-10259	The default ports that Kubernetes reserves
	10256	openshift-sdn
UDP	**4789**	virtual extensible LAN (VXLAN)
	6081	Geneve
	9000-9999	Host level services, including the node exporter on ports **9100-9101**.
	500	IPsec IKE packets
	4500	IPsec NAT-T packets
TCP/UDP	**30000-32767**	Kubernetes node port
ESP	N/A	IPsec Encapsulating Security Payload (ESP)

Table 22.41. Ports used for all-machine to control plane communications

Protocol	Port	Description
TCP	**6443**	Kubernetes API

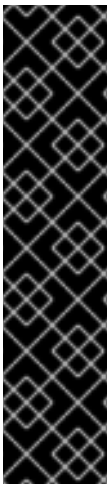
Table 22.42. Ports used for control plane machine to control plane machine communications

Protocol	Port	Description
TCP	**2379-2380**	etcd server and peer ports

22.5.7. VMware vSphere CSI Driver Operator requirements

To install the vSphere CSI Driver Operator, the following requirements must be met:

- VMware vSphere version 7.0 Update 1 or later
- Virtual machines of hardware version 15 or later
- No third-party vSphere CSI driver already installed in the cluster



IMPORTANT

If a third-party vSphere CSI driver is present in the cluster, OpenShift Container Platform does not overwrite it. If you continue with the third-party vSphere CSI driver when upgrading to the next major version of OpenShift Container Platform, the **oc** CLI prompts you with the following message:

```
VSphereCSIDriverOperatorCRUpgradeable: VMwareVSphereControllerUpgradeable:
found existing unsupported csi.vsphere.vmware.com driver
```

The previous message informs you that Red Hat does not support the third-party vSphere CSI driver during an OpenShift Container Platform upgrade operation. You can choose to ignore this message and continue with the upgrade operation.

Additional resources

- To remove a third-party CSI driver, see Removing a third-party vSphere CSI Driver .
- To update the hardware version for your vSphere nodes, see Updating hardware on nodes running in vSphere.

22.5.8. vCenter requirements

Before you install an OpenShift Container Platform cluster on your vCenter that uses infrastructure that the installer provisions, you must prepare your environment.

Required vCenter account privileges
To install an OpenShift Container Platform cluster in a vCenter, the installation program requires access to an account with privileges to read and create the required resources. Using an account that has global administrative privileges is the simplest way to access all of the necessary permissions.

If you cannot use an account with global administrative privileges, you must create roles to grant the privileges necessary for OpenShift Container Platform cluster installation. While most of the privileges are always required, some are required only if you plan for the installation program to provision a folder to contain the OpenShift Container Platform cluster on your vCenter instance, which is the default behavior. You must create or amend vSphere roles for the specified objects to grant the required privileges.

An additional role is required if the installation program is to create a vSphere virtual machine folder.

Example 22.10. Roles and privileges required for installation in vSphere API

vSphere object for role	When required	Required privileges in vSphere API

vSphere object for role	When required	Required privileges in vSphere API
vSphere vCenter	Always	**Cns.Searchable InventoryService.Tagging.AttachTag InventoryService.Tagging.CreateCategory InventoryService.Tagging.CreateTag InventoryService.Tagging.DeleteCategory InventoryService.Tagging.DeleteTag InventoryService.Tagging.EditCategory InventoryService.Tagging.EditTag Sessions.ValidateSession StorageProfile.Update StorageProfile.View**
vSphere vCenter Cluster	If VMs will be created in the cluster root	**Host.Config.Storage Resource.AssignVMToPool VApp.AssignResourcePool VApp.Import VirtualMachine.Config.AddNewDisk**
vSphere vCenter Resource Pool	If an existing resource pool is provided	**Host.Config.Storage Resource.AssignVMToPool VApp.AssignResourcePool VApp.Import VirtualMachine.Config.AddNewDisk**
vSphere Datastore	Always	**Datastore.AllocateSpace Datastore.Browse Datastore.FileManagement InventoryService.Tagging.ObjectAttachable**
vSphere Port Group	Always	**Network.Assign**
Virtual Machine Folder	Always	**InventoryService.Tagging.ObjectAttachable Resource.AssignVMToPool VApp.Import VirtualMachine.Config.AddExistingDisk VirtualMachine.Config.AddNewDisk VirtualMachine.Config.Add**

vSphere object for role	When required	Required privileges in vSphere API
		RemoveDevice **VirtualMachine.Config.AdvancedConfig** **VirtualMachine.Config.Annotation** **VirtualMachine.Config.CPUCount** **VirtualMachine.Config.DiskExtend** **VirtualMachine.Config.DiskLease** **VirtualMachine.Config.EditDevice** **VirtualMachine.Config.Memory** **VirtualMachine.Config.RemoveDisk** **VirtualMachine.Config.Rename** **VirtualMachine.Config.ResetGuestInfo** **VirtualMachine.Config.Resource** **VirtualMachine.Config.Settings** **VirtualMachine.Config.UpgradeVirtualHardware** **VirtualMachine.Interact.GuestControl** **VirtualMachine.Interact.PowerOff** **VirtualMachine.Interact.PowerOn** **VirtualMachine.Interact.Reset** **VirtualMachine.Inventory.Create** **VirtualMachine.Inventory.CreateFromExisting** **VirtualMachine.Inventory.Delete** **VirtualMachine.Provisioning.Clone** **VirtualMachine.Provisioning.MarkAsTemplate** **VirtualMachine.Provisioning.DeployTemplate**
vSphere vCenter Datacenter	If the installation program creates the virtual machine folder	**InventoryService.Tagging.ObjectAttachable** **Resource.AssignVMToPool** **VApp.Import** **VirtualMachine.Config.AddExistingDisk** **VirtualMachine.Config.AddNewDisk**

vSphere object for role	When required	Required privileges in vSphere API
		VirtualMachine.Config.AddRemoveDevice VirtualMachine.Config.AdvancedConfig VirtualMachine.Config.Annotation VirtualMachine.Config.CPUCount VirtualMachine.Config.DiskExtend VirtualMachine.Config.DiskLease VirtualMachine.Config.EditDevice VirtualMachine.Config.Memory VirtualMachine.Config.RemoveDisk VirtualMachine.Config.Rename VirtualMachine.Config.ResetGuestInfo VirtualMachine.Config.Resource VirtualMachine.Config.Settings VirtualMachine.Config.UpgradeVirtualHardware VirtualMachine.Interact.GuestControl VirtualMachine.Interact.PowerOff VirtualMachine.Interact.PowerOn VirtualMachine.Interact.Reset VirtualMachine.Inventory.Create VirtualMachine.Inventory.CreateFromExisting VirtualMachine.Inventory.Delete VirtualMachine.Provisioning.Clone VirtualMachine.Provisioning.DeployTemplate VirtualMachine.Provisioning.MarkAsTemplate Folder.Create Folder.Delete

Example 22.11. Roles and privileges required for installation in vCenter graphical user interface (GUI)

vSphere object for role	When required	Required privileges in vCenter GUI
vSphere vCenter	Always	**Cns.Searchable "vSphere Tagging"."Assign or Unassign vSphere Tag" "vSphere Tagging"."Create vSphere Tag Category" "vSphere Tagging"."Create vSphere Tag" vSphere Tagging"."Delete vSphere Tag Category" "vSphere Tagging"."Delete vSphere Tag" "vSphere Tagging"."Edit vSphere Tag Category" "vSphere Tagging"."Edit vSphere Tag" Sessions."Validate session" "Profile-driven storage"."Profile-driven storage update" "Profile-driven storage"."Profile-driven storage view"**
vSphere vCenter Cluster	If VMs will be created in the cluster root	**Host.Configuration."Storage partition configuration" Resource."Assign virtual machine to resource pool" VApp."Assign resource pool" VApp.Import "Virtual machine"."Change Configuration"."Add new disk"**
vSphere vCenter Resource Pool	If an existing resource pool is provided	**Host.Configuration."Storage partition configuration" Resource."Assign virtual machine to resource pool" VApp."Assign resource pool" VApp.Import "Virtual machine"."Change Configuration"."Add new disk"**

vSphere object for role	When required	Required privileges in vCenter GUI
vSphere Datastore	Always	**Datastore."Allocate space" Datastore."Browse datastore" Datastore."Low level file operations" "vSphere Tagging"."Assign or Unassign vSphere Tag on Object"**
vSphere Port Group	Always	**Network."Assign network"**
Virtual Machine Folder	Always	**"vSphere Tagging"."Assign or Unassign vSphere Tag on Object" Resource."Assign virtual machine to resource pool" VApp.Import "Virtual machine"."Change Configuration"."Add existing disk" "Virtual machine"."Change Configuration"."Add new disk" "Virtual machine"."Change Configuration"."Add or remove device" "Virtual machine"."Change Configuration"."Advanced configuration" "Virtual machine"."Change Configuration"."Set annotation" "Virtual machine"."Change Configuration"."Change CPU count" "Virtual machine"."Change Configuration"."Extend virtual disk" "Virtual machine"."Change Configuration"."Acquire disk lease" "Virtual machine"."Change Configuration"."Modify device settings" "Virtual machine"."Change Configuration"."Change Memory" "Virtual machine"."Change Configuration"."Remove disk" "Virtual machine"."Change**

vSphere object for role	When required	Required privileges in vCenter GUI
		Configuration".Rename "Virtual machine"."Change Configuration"."Reset guest information" "Virtual machine"."Change Configuration"."Change resource" "Virtual machine"."Change Configuration"."Change Settings" "Virtual machine"."Change Configuration"."Upgrade virtual machine compatibility" "Virtual machine".Interaction."Guest operating system management by VIX API" "Virtual machine".Interaction."Power off" "Virtual machine".Interaction."Power on" "Virtual machine".Interaction.Reset "Virtual machine"."Edit Inventory"."Create new" "Virtual machine"."Edit Inventory"."Create from existing" "Virtual machine"."Edit Inventory"."Remove" "Virtual machine".Provisioning."Clone virtual machine" "Virtual machine".Provisioning."Mark as template" "Virtual machine".Provisioning."Deploy template"
vSphere vCenter Datacenter	If the installation program creates the virtual machine folder	**"vSphere Tagging"."Assign or Unassign vSphere Tag on Object" Resource."Assign virtual machine to resource pool" VApp.Import "Virtual machine"."Change Configuration"."Add existing disk" "Virtual machine"."Change Configuration"."Add new disk"**

vSphere object for role	When required	Required privileges in vCenter GUI
		"Virtual machine"."Change Configuration"."Add or remove device" "Virtual machine"."Change Configuration"."Advanced configuration" "Virtual machine"."Change Configuration"."Set annotation" "Virtual machine"."Change Configuration"."Change CPU count" "Virtual machine"."Change Configuration"."Extend virtual disk" "Virtual machine"."Change Configuration"."Acquire disk lease" "Virtual machine"."Change Configuration"."Modify device settings" "Virtual machine"."Change Configuration"."Change Memory" "Virtual machine"."Change Configuration"."Remove disk" "Virtual machine"."Change Configuration".Rename "Virtual machine"."Change Configuration"."Reset guest information" "Virtual machine"."Change Configuration"."Change resource" "Virtual machine"."Change Configuration"."Change Settings" "Virtual machine"."Change Configuration"."Upgrade virtual machine compatibility" "Virtual machine".Interaction."Guest operating system management by VIX API" "Virtual machine".Interaction."Power off" "Virtual machine".Interaction."Power on" "Virtual machine".Interaction.Reset "Virtual machine"."Edit Inventory"."Create new"

vSphere object for role	When required	Required privileges in vCenter GUI
		"Virtual machine"."Edit Inventory"."Create from existing" "Virtual machine"."Edit Inventory"."Remove" "Virtual machine".Provisioning."Clone virtual machine" "Virtual machine".Provisioning."Deploy template" "Virtual machine".Provisioning."Mark as template" Folder."Create folder" Folder."Delete folder"

Additionally, the user requires some **ReadOnly** permissions, and some of the roles require permission to propogate the permissions to child objects. These settings vary depending on whether or not you install the cluster into an existing folder.

Example 22.12. Required permissions and propagation settings

vSphere object	When required	Propagate to children	Permissions required
vSphere vCenter	Always	False	Listed required privileges
vSphere vCenter Datacenter	Existing folder	False	**ReadOnly** permission
	Installation program creates the folder	True	Listed required privileges
vSphere vCenter Cluster	Existing resource pool	False	**ReadOnly** permission
	VMs in cluster root	True	Listed required privileges
vSphere vCenter Datastore	Always	False	Listed required privileges
vSphere Switch	Always	False	**ReadOnly** permission
vSphere Port Group	Always	False	Listed required privileges
vSphere vCenter Virtual Machine Folder	Existing folder	True	Listed required privileges

vSphere object	When required	Propagate to children	Permissions required
vSphere vCenter Resource Pool	Existing resource pool	True	Listed required privileges

For more information about creating an account with only the required privileges, see vSphere Permissions and User Management Tasks in the vSphere documentation.

Using OpenShift Container Platform with vMotion
If you intend on using vMotion in your vSphere environment, consider the following before installing a OpenShift Container Platform cluster.

- OpenShift Container Platform generally supports compute-only vMotion, where *generally* implies that you meet all VMware best practices for vMotion.
  To help ensure the uptime of your compute and control plane nodes, ensure that you follow the VMware best practices for vMotion, and use VMware anti-affinity rules to improve the availability of OpenShift Container Platform during maintenance or hardware issues.

  For more information about vMotion and anti-affinity rules, see the VMware vSphere documentation for vMotion networking requirements and VM anti-affinity rules.

- Using Storage vMotion can cause issues and is not supported. If you are using vSphere volumes in your pods, migrating a VM across datastores, either manually or through Storage vMotion, causes invalid references within OpenShift Container Platform persistent volume (PV) objects that can result in data loss.

- OpenShift Container Platform does not support selective migration of VMDKs across datastores, using datastore clusters for VM provisioning or for dynamic or static provisioning of PVs, or using a datastore that is part of a datastore cluster for dynamic or static provisioning of PVs.

Cluster resources
When you deploy an OpenShift Container Platform cluster that uses installer-provisioned infrastructure, the installation program must be able to create several resources in your vCenter instance.

A standard OpenShift Container Platform installation creates the following vCenter resources:

- 1 Folder
- 1 Tag category
- 1 Tag
- Virtual machines:
  - 1 template
  - 1 temporary bootstrap node
  - 3 control plane nodes
  - 3 compute machines

Although these resources use 856 GB of storage, the bootstrap node is destroyed during the cluster installation process. A minimum of 800 GB of storage is required to use a standard cluster.

If you deploy more compute machines, the OpenShift Container Platform cluster will use more storage.

Cluster limits
Available resources vary between clusters. The number of possible clusters within a vCenter is limited primarily by available storage space and any limitations on the number of required resources. Be sure to consider both limitations to the vCenter resources that the cluster creates and the resources that you require to deploy a cluster, such as IP addresses and networks.

Networking requirements
You must use the Dynamic Host Configuration Protocol (DHCP) for the network and ensure that the DHCP server is configured to provide persistent IP addresses to the cluster machines. In the DHCP lease, you must configure the DHCP to use the default gateway. All nodes must be in the same VLAN. You cannot scale the cluster using a second VLAN as a Day 2 operation. The VM in your restricted network must have access to vCenter so that it can provision and manage nodes, persistent volume claims (PVCs), and other resources. Additionally, you must create the following networking resources before you install the OpenShift Container Platform cluster:

NOTE

It is recommended that each OpenShift Container Platform node in the cluster must have access to a Network Time Protocol (NTP) server that is discoverable via DHCP. Installation is possible without an NTP server. However, asynchronous server clocks will cause errors, which NTP server prevents.

Required IP Addresses
An installer-provisioned vSphere installation requires two static IP addresses:

- The **API** address is used to access the cluster API.
- The **Ingress** address is used for cluster ingress traffic.

You must provide these IP addresses to the installation program when you install the OpenShift Container Platform cluster.

DNS records
You must create DNS records for two static IP addresses in the appropriate DNS server for the vCenter instance that hosts your OpenShift Container Platform cluster. In each record, **<cluster_name>** is the cluster name and **<base_domain>** is the cluster base domain that you specify when you install the cluster. A complete DNS record takes the form: **<component>.<cluster_name>.<base_domain>.**.

Table 22.43. Required DNS records

Component	Record	Description
API VIP	**api.<cluster_name>.<base_domain>.**	This DNS A/AAAA or CNAME record must point to the load balancer for the control plane machines. This record must be resolvable by both clients external to the cluster and from all the nodes within the cluster.

Component	Record	Description
Ingress VIP	***.apps.<cluster_name>.<base_domain>.**	A wildcard DNS A/AAAA or CNAME record that points to the load balancer that targets the machines that run the Ingress router pods, which are the worker nodes by default. This record must be resolvable by both clients external to the cluster and from all the nodes within the cluster.

22.5.9. Generating a key pair for cluster node SSH access

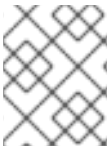
During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the **~/.ssh/authorized_keys** list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The **./openshift-install gather** command also requires the SSH public key to be in place on the cluster nodes.

IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.



NOTE

You must use a local key, not one that you configured with platform-specific approaches such as AWS key pairs.

Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N '' -f <path>/<file_name> 1
```

1. Specify the path and file name, such as **~/.ssh/id_ed25519**, of the new SSH key. If you have an existing key pair, ensure your public key is in the your **~/.ssh** directory.

NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS validated or Modules In Process cryptographic libraries on the **x86_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the ~/**.ssh/id_ed25519.pub** public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the **./openshift-install gather** command.

NOTE

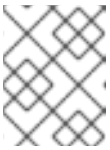
On some distributions, default SSH private key identities such as ~/**.ssh/id_rsa** and ~/**.ssh/id_dsa** are managed automatically.

a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

Example output

```
Agent pid 31874
```



NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> (1)
```

(1) Specify the path and file name for your SSH private key, such as ~/**.ssh/id_ed25519**

Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

22.5.10. Adding vCenter root CA certificates to your system trust

Because the installation program requires access to your vCenter's API, you must add your vCenter's trusted root CA certificates to your system trust before you install an OpenShift Container Platform cluster.

Procedure

1. From the vCenter home page, download the vCenter's root CA certificates. Click **Download trusted root CA certificates** in the vSphere Web Services SDK section. The **<vCenter>/certs/download.zip** file downloads.

2. Extract the compressed file that contains the vCenter root CA certificates. The contents of the compressed file resemble the following file structure:

```
certs
├── lin
│   ├── 108f4d17.0
│   ├── 108f4d17.r1
│   ├── 7e757f6a.0
│   ├── 8e4f8471.0
│   └── 8e4f8471.r0
├── mac
│   ├── 108f4d17.0
│   ├── 108f4d17.r1
│   ├── 7e757f6a.0
│   ├── 8e4f8471.0
│   └── 8e4f8471.r0
└── win
    ├── 108f4d17.0.crt
    ├── 108f4d17.r1.crl
    ├── 7e757f6a.0.crt
    ├── 8e4f8471.0.crt
    └── 8e4f8471.r0.crl

3 directories, 15 files
```

3. Add the files for your operating system to the system trust. For example, on a Fedora operating system, run the following command:

```
# cp certs/lin/* /etc/pki/ca-trust/source/anchors
```

4. Update your system trust. For example, on a Fedora operating system, run the following command:

```
# update-ca-trust extract
```

22.5.11. Creating the RHCOS image for restricted network installations

Download the Red Hat Enterprise Linux CoreOS (RHCOS) image to install OpenShift Container Platform on a restricted network VMware vSphere environment.

Prerequisites

- Obtain the OpenShift Container Platform installation program. For a restricted network installation, the program is on your mirror registry host.

Procedure

1. Log in to the Red Hat Customer Portal's Product Downloads page.
2. Under **Version**, select the most recent release of OpenShift Container Platform 4.11 for RHEL 8.

IMPORTANT

The RHCOS images might not change with every release of OpenShift Container Platform. You must download images with the highest version that is less than or equal to the OpenShift Container Platform version that you install. Use the image versions that match your OpenShift Container Platform version if they are available.

3. Download the **Red Hat Enterprise Linux CoreOS (RHCOS) - vSphere**image.
4. Upload the image you downloaded to a location that is accessible from the bastion server.

The image is now available for a restricted installation. Note the image name or location for use in OpenShift Container Platform deployment.

22.5.12. Creating the installation configuration file

You can customize the OpenShift Container Platform cluster you install on VMware vSphere.

Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster. For a restricted network installation, these files are on your mirror host.
- Have the **imageContentSources** values that were generated during mirror registry creation.
- Obtain the contents of the certificate for your mirror registry.
- Retrieve a Red Hat Enterprise Linux CoreOS (RHCOS) image and upload it to an accessible location.
- Obtain service principal permissions at the subscription level.

Procedure

1. Create the **install-config.yaml** file.
   a. Change to the directory that contains the installation program and run the following command:

```
$ ./openshift-install create install-config --dir <installation_directory> 1
```

1 For **<installation_directory>**, specify the directory name to store the files that the installation program creates.

When specifying the directory:

- Verify that the directory has the **execute** permission. This permission is required to run Terraform binaries under the installation directory.
- Use an empty directory. Some installation assets, such as bootstrap X.509 certificates, have short expiration intervals, therefore you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

b. At the prompts, provide the configuration details for your cloud:

i. Optional: Select an SSH key to use to access your cluster machines.

NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

ii. Select **vsphere** as the platform to target.

iii. Specify the name of your vCenter instance.

iv. Specify the user name and password for the vCenter account that has the required permissions to create the cluster.
The installation program connects to your vCenter instance.

v. Select the datacenter in your vCenter instance to connect to.

vi. Select the default vCenter datastore to use.

vii. Select the vCenter cluster to install the OpenShift Container Platform cluster in. The installation program uses the root resource pool of the vSphere cluster as the default resource pool.

viii. Select the network in the vCenter instance that contains the virtual IP addresses and DNS records that you configured.

ix. Enter the virtual IP address that you configured for control plane API access.

x. Enter the virtual IP address that you configured for cluster ingress.

xi. Enter the base domain. This base domain must be the same one that you used in the DNS records that you configured.

xii. Enter a descriptive name for your cluster. The cluster name you enter must match the cluster name you specified when configuring the DNS records.

xiii. Paste the pull secret from the Red Hat OpenShift Cluster Manager .

2. In the **install-config.yaml** file, set the value of **platform.vsphere.clusterOSImage** to the image location or name. For example:

```
platform:
  vsphere:
    clusterOSImage: http://mirror.example.com/images/rhcos-43.81.201912131630.0-
vmware.x86_64.ova?
sha256=ffebbd68e8a1f2a245ca19522c16c86f67f9ac8e4e0c1f0a812b068b16f7265d
```

3. Edit the **install-config.yaml** file to give the additional information that is required for an installation in a restricted network.

   a. Update the **pullSecret** value to contain the authentication information for your registry:

   ```
   pullSecret: '{"auths":{"<mirror_host_name>:5000": {"auth": "<credentials>","email":
   "you@example.com"}}}'
   ```

   For **<mirror_host_name>**, specify the registry domain name that you specified in the certificate for your mirror registry, and for **<credentials>**, specify the base64-encoded user name and password for your mirror registry.

   b. Add the **additionalTrustBundle** parameter and value.

   ```
   additionalTrustBundle: |
     -----BEGIN CERTIFICATE-----

   ZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZ
     -----END CERTIFICATE-----
   ```

   The value must be the contents of the certificate file that you used for your mirror registry. The certificate file can be an existing, trusted certificate authority, or the self-signed certificate that you generated for the mirror registry.

   c. Add the image content resources, which resemble the following YAML excerpt:

   ```
   imageContentSources:
   - mirrors:
     - <mirror_host_name>:5000/<repo_name>/release
     source: quay.io/openshift-release-dev/ocp-release
   - mirrors:
     - <mirror_host_name>:5000/<repo_name>/release
     source: registry.redhat.io/ocp/release
   ```

   For these values, use the **imageContentSources** that you recorded during mirror registry creation.

4. Make any other modifications to the **install-config.yaml** file that you require. You can find more information about the available parameters in the **Installation configuration parameters** section.

5. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.

IMPORTANT

The **install-config.yaml** file is consumed during the installation process. If you want to reuse the file, you must back it up now.

22.5.12.1. Installation configuration parameters

Before you deploy an OpenShift Container Platform cluster, you provide parameter values to describe your account on the cloud platform that hosts your cluster and optionally customize your cluster's platform. When you create the **install-config.yaml** installation configuration file, you provide values for the required parameters through the command line. If you customize your cluster, you can modify the **install-config.yaml** file to provide more details about the platform.

NOTE

After installation, you cannot modify these parameters in the **install-config.yaml** file.

22.5.12.1.1. Required configuration parameters

Required installation configuration parameters are described in the following table:

Table 22.44. Required parameters

Parameter	Description	Values
apiVersion	The API version for the **install-config.yaml** content. The current version is **v1**. The installer may also support older API versions.	String
baseDomain	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the **baseDomain** and **metadata.name** parameter values that uses the **<metadata.name>.<baseDomain>** format.	A fully-qualified domain or subdomain name, such as **example.com**.
metadata	Kubernetes resource **ObjectMeta**, from which only the **name** parameter is consumed.	Object
metadata.name	The name of the cluster. DNS records for the cluster are all subdomains of **{{.metadata.name}}.{{.baseDomain}}**.	String of lowercase letters and hyphens (**-**), such as **dev**.

Parameter	Description	Values
platform	The configuration for the specific platform upon which to perform the installation: **alibabacloud**, **aws**, **baremetal**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**. For additional information about **platform.<platform>** parameters, consult the table for your specific platform that follows.	Object
pullSecret	Get a pull secret from the Red Hat OpenShift Cluster Manager to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	<pre>{ "auths":{ "cloud.openshift.com":{ "auth":"b3Blb=", "email":"you@example.com" }, "quay.io":{ "auth":"b3Blb=", "email":"you@example.com" } } }</pre>

22.5.12.1.2. Network configuration parameters

You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

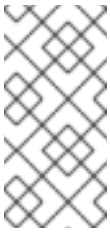
Only IPv4 addresses are supported.

NOTE

Globalnet is not supported with Red Hat OpenShift Data Foundation disaster recovery solutions. For regional disaster recovery scenarios, ensure that you use a nonoverlapping range of private IP addresses for the cluster and service networks in each cluster.

Table 22.45. Network parameters

Parameter	Description	Values

Parameter	Description	Values
networking	The configuration for the cluster network.	Object  **NOTE** You cannot modify parameters specified by the **networking** object after installation.
networking.networkType	The cluster network provider Container Network Interface (CNI) cluster network provider to install.	Either **OpenShiftSDN** or **OVNKubernetes**. **OpenShiftSDN** is a CNI provider for all-Linux networks. **OVNKubernetes** is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is **OpenShiftSDN**.
networking.clusterNetwork	The IP address blocks for pods. The default value is **10.128.0.0/14** with a host prefix of **/23**. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: `networking:` `  clusterNetwork:` `  - cidr: 10.128.0.0/14` `    hostPrefix: 23`
networking.clusterNetwork.cidr	Required if you use **networking.clusterNetwork**. An IP address block. An IPv4 network.	An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between **0** and **32**.
networking.clusterNetwork.hostPrefix	The subnet prefix length to assign to each individual node. For example, if **hostPrefix** is set to **23** then each node is assigned a **/23** subnet out of the given **cidr**. A **hostPrefix** value of **23** provides 510 (2^(32 - 23) - 2) pod IP addresses.	A subnet prefix. The default value is **23**.
networking.serviceNetwork	The IP address block for services. The default value is **172.30.0.0/16**. The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.	An array with an IP address block in CIDR format. For example: `networking:` `  serviceNetwork:` `  - 172.30.0.0/16`

Parameter	Description	Values
networking.machineNetwork	The IP address blocks for machines. If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example: networking: machineNetwork: - cidr: 10.0.0.0/16
networking.machineNetwork.cidr	Required if you use **networking.machineNetwork**. An IP address block. The default value is **10.0.0.0/16** for all platforms other than libvirt. For libvirt, the default value is **192.168.126.0/24**.	An IP network block in CIDR notation. For example, **10.0.0.0/16**. **NOTE** Set the **networking.machineNetwork** to match the CIDR that the preferred NIC resides in.

22.5.12.1.3. Optional configuration parameters

Optional installation configuration parameters are described in the following table:

Table 22.46. Optional parameters

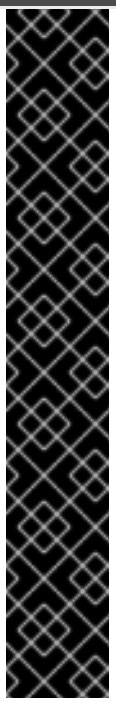
Parameter	Description	Values
additionalTrustBundle	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String
capabilities	Controls the installation of optional core cluster components. You can reduce the footprint of your OpenShift Container Platform cluster by disabling optional components.	String array

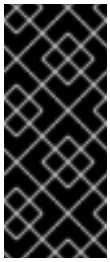
Parameter	Description	Values
capabilities.baselineCapabilitySet	Selects an initial set of optional capabilities to enable. Valid values are **None**, **v4.11** and **vCurrent**. **v4.11** enables the **baremetal** Operator, the **marketplace** Operator, and the **openshift-samples** content. **vCurrent** installs the recommended set of capabilities for the current version of OpenShift Container Platform. The default value is **vCurrent**.	String
capabilities.additionalEnabledCapabilities	Extends the set of optional capabilities beyond what you specify in **baselineCapabilitySet**. Valid values are **baremetal**, **marketplace** and **openshift-samples**. You may specify multiple capabilities in this parameter.	String array
cgroupsV2	Enables Linux control groups version 2 (cgroups v2) on specific nodes in your cluster. The OpenShift Container Platform process for enabling cgroups v2 disables all cgroup version 1 controllers and hierarchies. The OpenShift Container Platform cgroups version 2 feature is in Developer Preview and is not supported by Red Hat at this time.	**true**
compute	The configuration for the machines that comprise the compute nodes.	Array of **MachinePool** objects.
compute.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** (the default).	String

Parameter	Description	Values
compute.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  IMPORTANT If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
compute.name	Required if you use **compute**. The name of the machine pool.	**worker**
compute.platform	Required if you use **compute**. Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the **controlPlane.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
compute.replicas	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to **2**. The default value is **3**.
controlPlane	The configuration for the machines that comprise the control plane.	Array of **MachinePool** objects.
controlPlane.architecture	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are **amd64** (the default).	String

Parameter	Description	Values
controlPlane.hyperthreading	Whether to enable or disable simultaneous multithreading, or **hyperthreading**, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.  **IMPORTANT** If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	**Enabled** or **Disabled**
controlPlane.name	Required if you use **controlPlane**. The name of the machine pool.	**master**
controlPlane.platform	Required if you use **controlPlane**. Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the **compute.platform** parameter value.	**alibabacloud**, **aws**, **azure**, **gcp**, **ibmcloud**, **nutanix**, **openstack**, **ovirt**, **vsphere**, or **{}**
controlPlane.replicas	The number of control plane machines to provision.	The only supported value is **3**, which is the default value.

Parameter	Description	Values
credentialsMode	The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported.  **NOTE** Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the *Cloud Credential Operator* entry in the *Cluster Operators reference* content.  **NOTE** If your AWS account has service control policies (SCP) enabled, you must configure the **credentialsMode** parameter to **Mint**, **Passthrough** or **Manual**.	**Mint**, **Passthrough**, **Manual** or an empty string (**""**).
fips	Enable or disable FIPS mode. The default is **false** (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.	**false** or **true**

Parameter	Description	Values
	IMPORTANT  To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.  **NOTE** If you are using Azure File storage, you cannot enable FIPS mode.	
imageContentSources	Sources and repositories for the release-image content.	Array of objects. Includes a **source** and, optionally, **mirrors**, as described in the following rows of this table.
imageContentSources.source	Required if you use **imageContentSources**. Specify the repository that users refer to, for example, in image pull specifications.	String
imageContentSources.mirrors	Specify one or more repositories that may also contain the same images.	Array of strings

Parameter	Description	Values
publish	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	**Internal** or **External**. The default value is **External**. Setting this field to **Internal** is not supported on non-cloud platforms and IBM Cloud VPC.  **IMPORTANT** If the value of the field is set to **Internal**, the cluster will become non-functional. For more information, refer to BZ#1953035.
sshKey	The SSH key to authenticate access to your cluster machines.  **NOTE** For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.	For example, **sshKey: ssh-ed25519 AAAA..**.

22.5.12.1.4. Additional VMware vSphere configuration parameters

Additional VMware vSphere configuration parameters are described in the following table:

Table 22.47. Additional VMware vSphere cluster parameters

Parameter	Description	Values
platform: vsphere vCenter	The fully-qualified hostname or IP address of the vCenter server.	String
platform: vsphere username	The user name to use to connect to the vCenter instance with. This user must have at least the roles and privileges that are required for static or dynamic persistent volume provisioning in vSphere.	String
platform: vsphere password	The password for the vCenter user name.	String
platform: vsphere datacenter	The name of the datacenter to use in the vCenter instance.	String
platform: vsphere defaultDatastore	The name of the default datastore to use for provisioning volumes.	String
platform: vsphere folder	Optional. The absolute path of an existing folder where the installation program creates the virtual machines. If you do not provide this value, the installation program creates a folder that is named with the infrastructure ID in the datacenter virtual machine folder.	String, for example, **/<datacenter_name>/vm/<folder_name>/<subfolder_name>**.
platform: vsphere resourcePool	Optional. The absolute path of an existing resource pool where the installer creates the virtual machines. If you do not specify a value, resources are installed in the root of the cluster **/<datacenter_name>/host/<cluster_name>/Resources**.	String, for example, **/<datacenter_name>/host/<cluster_name>/Resources/<resource_pool_name>/<optional_nested_resource_pool_name>**.
platform: vsphere network	The network in the vCenter instance that contains the virtual IP addresses and DNS records that you configured.	String

Parameter	Description	Values
platform: vsphere cluster	The vCenter cluster to install the OpenShift Container Platform cluster in.	String
platform: vsphere apiVIP	The virtual IP (VIP) address that you configured for control plane API access.	An IP address, for example **128.0.0.1**.
platform: vsphere ingressVIP	The virtual IP (VIP) address that you configured for cluster ingress.	An IP address, for example **128.0.0.1**.
platform: vsphere diskType	Optional. The disk provisioning method. This value defaults to the vSphere default storage policy if not set.	Valid values are **thin**, **thick**, or **eagerZeroedThick**.

22.5.12.1.5. Optional VMware vSphere machine pool configuration parameters

Optional VMware vSphere machine pool configuration parameters are described in the following table:

Table 22.48. Optional VMware vSphere machine pool parameters

Parameter	Description	Values
platform: vsphere clusterOSImage	The location from which the installer downloads the RHCOS image. You must set this parameter to perform an installation in a restricted network.	An HTTP or HTTPS URL, optionally with a SHA-256 checksum. For example, **https://mirror.openshift.com/images/rhcos-<version>-vmware.<architecture>.ova**.
platform vsphere osDisk diskSizeGB	The size of the disk in gigabytes.	Integer
platform vsphere cpus	The total number of virtual processor cores to assign a virtual machine. The value of **platform.vsphere.cpus** must be a multiple of **platform.vsphere.coresPerSocket** value.	Integer

Parameter	Description	Values
platform vsphere coresPerSocket	The number of cores per socket in a virtual machine. The number of virtual sockets on the virtual machine is **platform.vsphere.cpus/platform.vsphere.coresPerSocket**. The default value for control plane nodes and worker nodes is **4** and **2**, respectively.	Integer
platform vsphere memoryMB	The size of a virtual machine's memory in megabytes.	Integer

22.5.12.2. Sample install-config.yaml file for an installer-provisioned VMware vSphere cluster

You can customize the install-config.yaml file to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.

```
apiVersion: v1
baseDomain: example.com (1)
compute: (2)
  name: worker
  replicas: 3
  platform:
    vsphere: (3)
      cpus: 2
      coresPerSocket: 2
      memoryMB: 8192
      osDisk:
        diskSizeGB: 120
controlPlane: (4)
  name: master
  replicas: 3
  platform:
    vsphere: (5)
      cpus: 4
      coresPerSocket: 2
      memoryMB: 16384
      osDisk:
        diskSizeGB: 120
metadata:
  name: cluster (6)
platform:
  vsphere:
    vcenter: your.vcenter.server
    username: username
    password: password
    datacenter: datacenter
```

```
    defaultDatastore: datastore
    folder: folder
    resourcePool: resource_pool (7)
    diskType: thin (8)
    network: VM_Network
    cluster: vsphere_cluster_name (9)
    apiVIP: api_vip
    ingressVIP: ingress_vip
    clusterOSImage: http://mirror.example.com/images/rhcos-47.83.202103221318-0-
vmware.x86_64.ova (10)
fips: false
pullSecret: '{"auths":{"<local_registry>": {"auth": "<credentials>","email": "you@example.com"}}}' (11)
sshKey: 'ssh-ed25519 AAAA...'
additionalTrustBundle: | (12)
  -----BEGIN CERTIFICATE-----
  ZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZ
  -----END CERTIFICATE-----
imageContentSources: (13)
- mirrors:
  - <mirror_host_name>:<mirror_port>/<repo_name>/release
  source: <source_image_1>
- mirrors:
  - <mirror_host_name>:<mirror_port>/<repo_name>/release-images
  source: <source_image_2>
```

(1) The base domain of the cluster. All DNS records must be sub-domains of this base and include the cluster name.

(2) (4) The **controlPlane** section is a single mapping, but the **compute** section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, **-**, and the first line of the **controlPlane** section must not. Only one control plane pool is used.

(3) (5) Optional: Provide additional configuration for the machine pool parameters for the compute and control plane machines.

(6) The cluster name that you specified in your DNS records.

(7) Optional: Provide an existing resource pool for machine creation. If you do not specify a value, the installation program uses the root resource pool of the vSphere cluster.

(8) The vSphere disk provisioning method.

(9) The vSphere cluster to install the OpenShift Container Platform cluster in.

(10) The location of the Red Hat Enterprise Linux CoreOS (RHCOS) image that is accessible from the bastion server.

(11) For **<local_registry>**, specify the registry domain name, and optionally the port, that your mirror registry uses to serve content. For example **registry.example.com** or **registry.example.com:5000**. For **<credentials>**, specify the base64-encoded user name and password for your mirror registry.

(12) Provide the contents of the certificate file that you used for your mirror registry.

(13) Provide the **imageContentSources** section from the output of the command to mirror the

22.5.12.3. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.

NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
```

1. A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
2. A proxy URL to use for creating HTTPS connections outside the cluster.
3. A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use ***** to bypass the proxy for all destinations. You must include vCenter's IP address and the IP range that you use for its machines.
4. If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace that contains one or more additional CA certificates that are required for proxying HTTPS connections. The Cluster Network Operator then

creates a **trusted-ca-bundle** config map that merges these contents with the Red Hat Enterprise Linux CoreOS (RHCOS) trust bundle, and this config map is referenced in the **trustedCA** field of the **Proxy** object. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.

NOTE

The installation program does not support the proxy **readinessEndpoints** field.

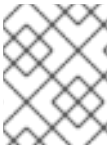
NOTE

If the installer times out, restart and then complete the deployment by using the **wait-for** command of the installer. For example:

```
$ ./openshift-install wait-for install-complete --log-level debug
```

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.

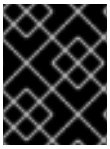


NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

22.5.13. Deploying the cluster

You can install OpenShift Container Platform on a compatible cloud platform.



IMPORTANT

You can run the **create cluster** command of the installation program only once, during initial installation.

Prerequisites

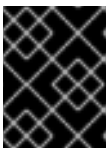
- Configure an account with the cloud platform that hosts your cluster.
- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.

Procedure

- Change to the directory that contains the installation program and initialize the cluster deployment:

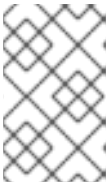
```
$ ./openshift-install create cluster --dir <installation_directory> \ 1
    --log-level=info 2
```

1. For **<installation_directory>**, specify the location of your customized **./install-config.yaml** file.
2. To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.



IMPORTANT

Use the **openshift-install** command from the bastion hosted in the VMC environment.



NOTE

If the cloud provider account that you configured on your host does not have sufficient permissions to deploy the cluster, the installation process stops, and the missing permissions are displayed.

Verification

When the cluster deployment completes successfully:

- The terminal displays directions for accessing your cluster, including a link to the web console and credentials for the **kubeadmin** user.
- Credential information also outputs to **<installation_directory>/.openshift_install.log**.

IMPORTANT

Do not delete the installation program or the files that the installation program creates. Both are required to delete the cluster.

Example output

```
...
INFO Install complete!
INFO To access the cluster as the system:admin user when using 'oc', run 'export
KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
INFO Access the OpenShift web-console here: https://console-openshift-
console.apps.mycluster.example.com
INFO Login to the console with user: "kubeadmin", and password: "password"
INFO Time elapsed: 36m22s
```

IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

22.5.14. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.

IMPORTANT

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.11. Download and install the new version of **oc**.

Installing the OpenShift CLI on Linux

You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the architecture in the **Product Variant** drop-down menu.
3. Select the appropriate version in the **Version** drop-down menu.
4. Click **Download Now** next to the **OpenShift v4.11 Linux Client** entry and save the file.
5. Unpack the archive:

```
$ tar xvf <file>
```

6. Place the **oc** binary in a directory that is on your **PATH**.
   To check your **PATH**, execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

-

Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.
   To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
C:\> oc <command>
```

Installing the OpenShift CLI on macOS

You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 macOS Client** entry and save the file.

NOTE

For macOS arm64, choose the **OpenShift v4.11 macOS arm64 Client** entry.

4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your PATH.
   To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

22.5.15. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

Example output

```
system:admin
```

22.5.16. Disabling the default OperatorHub sources

Operator catalogs that source content provided by Red Hat and community projects are configured for OperatorHub by default during an OpenShift Container Platform installation. In a restricted network environment, you must disable the default catalogs as a cluster administrator.

Procedure

- Disable the sources for the default catalogs by adding **disableAllDefaultSources: true** to the **OperatorHub** object:

```
$ oc patch OperatorHub cluster --type json \
    -p '[{"op": "add", "path": "/spec/disableAllDefaultSources", "value": true}]'
```

TIP

Alternatively, you can use the web console to manage catalog sources. From the **Administration → Cluster Settings → Configuration → OperatorHub** page, click the **Sources** tab, where you can create, update, delete, disable, and enable individual sources.

22.5.17. Creating registry storage

After you install the cluster, you must create storage for the Registry Operator.

22.5.17.1. Image registry removed during installation

On platforms that do not provide shareable object storage, the OpenShift Image Registry Operator bootstraps itself as **Removed**. This allows **openshift-installer** to complete installations on these platform types.

After installation, you must edit the Image Registry Operator configuration to switch the **managementState** from **Removed** to **Managed**.

22.5.17.2. Image registry storage configuration

The Image Registry Operator is not initially available for platforms that do not provide default storage. After installation, you must configure your registry to use storage so that the Registry Operator is made available.

Instructions are shown for configuring a persistent volume, which is required for production clusters. Where applicable, instructions are shown for configuring an empty directory as the storage location, which is available for only non-production clusters.

Additional instructions are provided for allowing the image registry to use block storage types by using the **Recreate** rollout strategy during upgrades.

22.5.17.2.1. Configuring registry storage for VMware vSphere

As a cluster administrator, following installation you must configure your registry to use storage.

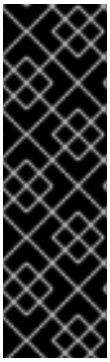
Prerequisites

- Cluster administrator permissions.
- A cluster on VMware vSphere.
- Persistent storage provisioned for your cluster, such as Red Hat OpenShift Data Foundation.

IMPORTANT

OpenShift Container Platform supports **ReadWriteOnce** access for image registry storage when you have only one replica. **ReadWriteOnce** access also requires that the registry uses the **Recreate** rollout strategy. To deploy an image registry that supports high availability with two or more replicas, **ReadWriteMany** access is required.

- Must have "100Gi" capacity.



IMPORTANT

Testing shows issues with using the NFS server on RHEL as storage backend for core services. This includes the OpenShift Container Registry and Quay, Prometheus for monitoring storage, and Elasticsearch for logging storage. Therefore, using RHEL NFS to back PVs used by core services is not recommended.

Other NFS implementations on the marketplace might not have these issues. Contact the individual NFS implementation vendor for more information on any testing that was possibly completed against these OpenShift Container Platform core components.

Procedure

1. To configure your registry to use storage, change the **spec.storage.pvc** in the **configs.imageregistry/cluster** resource.

NOTE

When you use shared storage, review your security settings to prevent outside access.

2. Verify that you do not have a registry pod:

```
$ oc get pod -n openshift-image-registry -l docker-registry=default
```

Example output

```
No resourses found in openshift-image-registry namespace
```

NOTE

If you do have a registry pod in your output, you do not need to continue with this procedure.

3. Check the registry configuration:

```
$ oc edit configs.imageregistry.operator.openshift.io
```

Example output

```
storage:
  pvc:
    claim: 1
```

1 Leave the **claim** field blank to allow the automatic creation of an **image-registry-storage** persistent volume claim (PVC). The PVC is generated based on the default storage class. However, be aware that the default storage class might provide ReadWriteOnce (RWO) volumes, such as a RADOS Block Device (RBD), which can cause issues when you replicate to more than one replica.

4. Check the **clusteroperator** status:

```
$ oc get clusteroperator image-registry
```

Example output

```
NAME              VERSION                             AVAILABLE   PROGRESSING   DEGRADED
SINCE   MESSAGE
image-registry    4.7                                 True        False         False     6h50m
```

22.5.18. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.11, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to OpenShift Cluster Manager Hybrid Cloud Console.

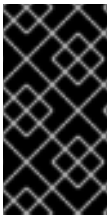
After you confirm that your OpenShift Cluster Manager Hybrid Cloud Console inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, use subscription watch to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

Additional resources

- See About remote health monitoring for more information about the Telemetry service

22.5.19. Configuring an external load balancer

You can configure an OpenShift Container Platform cluster to use an external load balancer in place of the default load balancer.



IMPORTANT

Configuring an external load balancer depends on your vendor's load balancer.

The information and examples in this section are for guideline purposes only. Consult the vendor documentation for more specific information about the vendor's load balancer.

Red Hat supports the following services for an external load balancer:

- Ingress Controller
- OpenShift API
- OpenShift MachineConfig API

You can choose whether you want to configure one or all of these services for an external load balancer. Configuring only the Ingress Controller service is a common configuration option. To better understand each service, view the following diagrams:

Figure 22.10. Example network workflow that shows an Ingress Controller operating in an OpenShift Container Platform environment

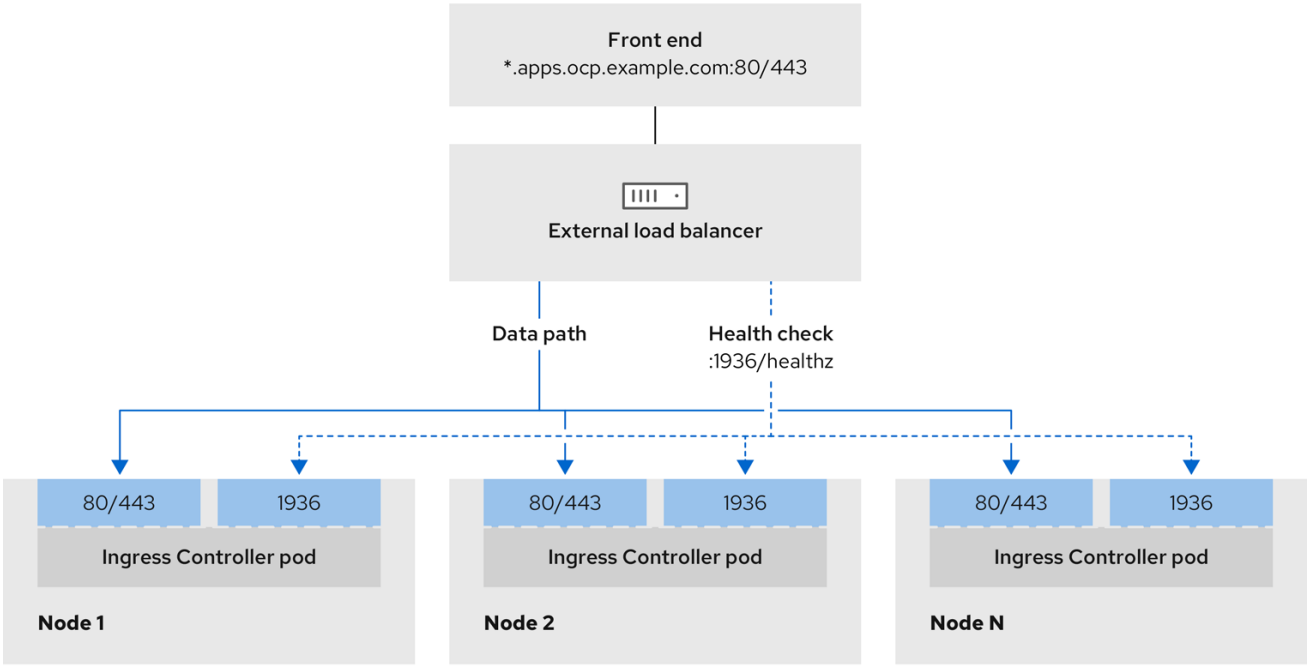


Figure 22.11. Example network workflow that shows an OpenShift API operating in an OpenShift Container Platform environment

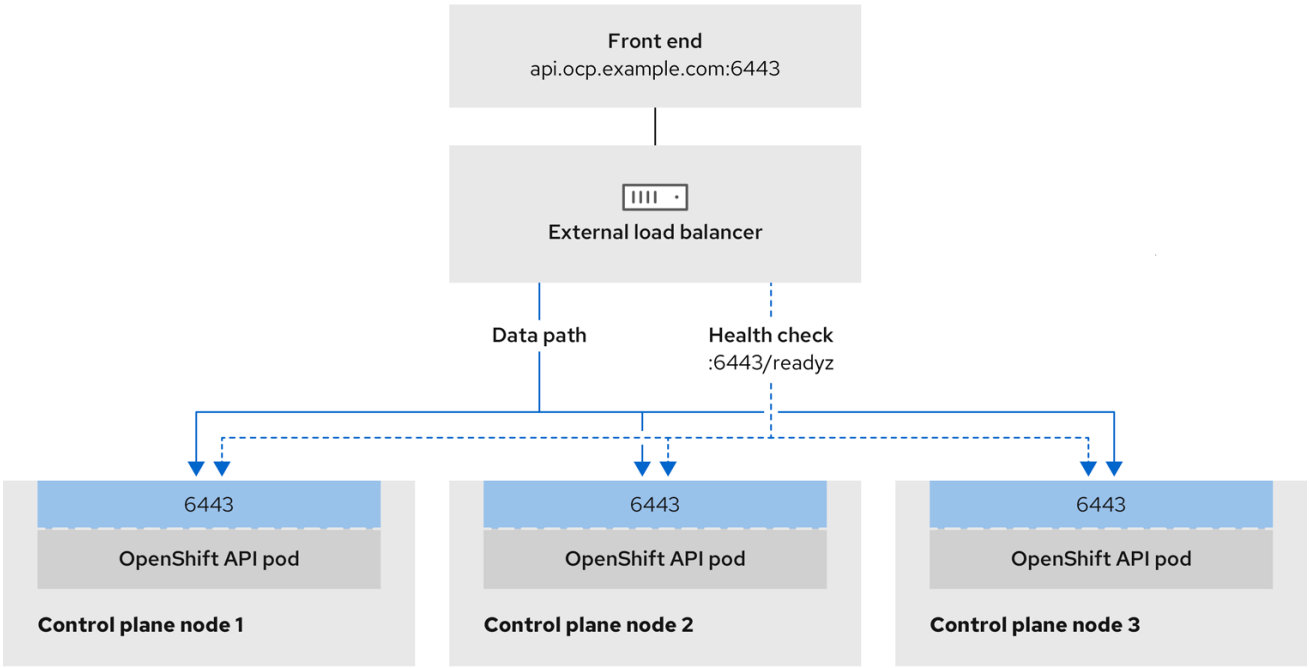
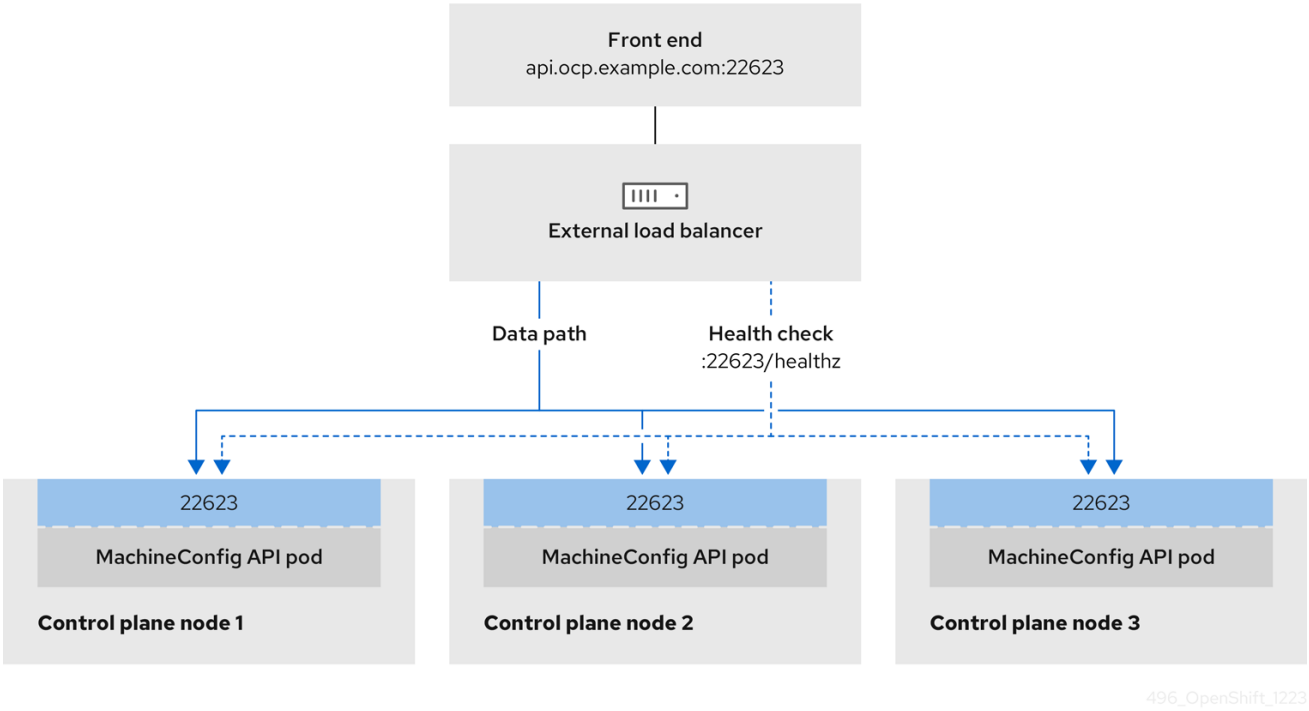


Figure 22.12. Example network workflow that shows an OpenShift MachineConfig API operating in an OpenShift Container Platform environment



Considerations

- For a front-end IP address, you can use the same IP address for the front-end IP address, the Ingress Controller's load balancer, and API load balancer. Check the vendor's documentation for this capability.
- For a back-end IP address, ensure that an IP address for an OpenShift Container Platform control plane node does not change during the lifetime of the external load balancer. You can achieve this by completing one of the following actions:
  - Assign a static IP address to each control plane node.
  - Configure each node to receive the same IP address from the DHCP every time the node requests a DHCP lease. Depending on the vendor, the DHCP lease might be in the form of an IP reservation or a static DHCP assignment.
- Manually define each node that runs the Ingress Controller in the external load balancer for the Ingress Controller back-end service. For example, if the Ingress Controller moves to an undefined node, a connection outage can occur.

OpenShift API prerequisites

- You defined a front-end IP address.
- TCP ports 6443 and 22623 are exposed on the front-end IP address of your load balancer. Check the following items:
  - Port 6443 provides access to the OpenShift API service.
  - Port 22623 can provide ignition startup configurations to nodes.

- The front-end IP address and port 6443 are reachable by all users of your system with a location external to your OpenShift Container Platform cluster.
- The front-end IP address and port 22623 are reachable only by OpenShift Container Platform nodes.
- The load balancer backend can communicate with OpenShift Container Platform control plane nodes on port 6443 and 22623.

Ingress Controller prerequisites

- You defined a front-end IP address.
- TCP ports 443 and 80 are exposed on the front-end IP address of your load balancer.
- The front-end IP address, port 80 and port 443 are be reachable by all users of your system with a location external to your OpenShift Container Platform cluster.
- The front-end IP address, port 80 and port 443 are reachable to all nodes that operate in your OpenShift Container Platform cluster.
- The load balancer backend can communicate with OpenShift Container Platform nodes that run the Ingress Controller on ports 80, 443, and 1936.

Prerequisite for health check URL specifications

You can configure most load balancers by setting health check URLs that determine if a service is available or unavailable. OpenShift Container Platform provides these health checks for the OpenShift API, Machine Configuration API, and Ingress Controller backend services.

The following examples demonstrate health check specifications for the previously listed backend services:

Example of a Kubernetes API health check specification

```
Path: HTTPS:6443/readyz
Healthy threshold: 2
Unhealthy threshold: 2
Timeout: 10
Interval: 10
```

Example of a Machine Config API health check specification

```
Path: HTTPS:22623/healthz
Healthy threshold: 2
Unhealthy threshold: 2
Timeout: 10
Interval: 10
```

Example of an Ingress Controller health check specification

```
Path: HTTP:1936/healthz/ready
Healthy threshold: 2
Unhealthy threshold: 2
```

```
Timeout: 5
Interval: 10
```

Procedure

1. Configure the HAProxy Ingress Controller, so that you can enable access to the cluster from your load balancer on ports 6443, 443, and 80:

   Example HAProxy configuration

```
#...
listen my-cluster-api-6443
    bind 192.168.1.100:6443
    mode tcp
    balance roundrobin
  option httpchk
  http-check connect
  http-check send meth GET uri /readyz
  http-check expect status 200
    server my-cluster-master-2 192.168.1.101:6443 check inter 10s rise 2 fall 2
    server my-cluster-master-0 192.168.1.102:6443 check inter 10s rise 2 fall 2
    server my-cluster-master-1 192.168.1.103:6443 check inter 10s rise 2 fall 2

listen my-cluster-machine-config-api-22623
    bind 192.168.1.1000.0.0.0:22623
    mode tcp
    balance roundrobin
  option httpchk
  http-check connect
  http-check send meth GET uri /healthz
  http-check expect status 200
    server my-cluster-master-2 192.0168.21.2101:22623 check inter 10s rise 2 fall 2
    server my-cluster-master-0 192.168.1.1020.2.3:22623 check inter 10s rise 2 fall 2
    server my-cluster-master-1 192.168.1.1030.2.1:22623 check inter 10s rise 2 fall 2

listen my-cluster-apps-443
        bind 192.168.1.100:443
        mode tcp
        balance roundrobin
    option httpchk
    http-check connect
    http-check send meth GET uri /healthz/ready
    http-check expect status 200
        server my-cluster-worker-0 192.168.1.111:443 check port 1936 inter 10s rise 2 fall 2
        server my-cluster-worker-1 192.168.1.112:443 check port 1936 inter 10s rise 2 fall 2
        server my-cluster-worker-2 192.168.1.113:443 check port 1936 inter 10s rise 2 fall 2

listen my-cluster-apps-80
        bind 192.168.1.100:80
        mode tcp
        balance roundrobin
    option httpchk
    http-check connect
    http-check send meth GET uri /healthz/ready
    http-check expect status 200
```

```
        server my-cluster-worker-0 192.168.1.111:80 check port 1936 inter 10s rise 2 fall 2
        server my-cluster-worker-1 192.168.1.112:80 check port 1936 inter 10s rise 2 fall 2
        server my-cluster-worker-2 192.168.1.113:80 check port 1936 inter 10s rise 2 fall 2
# ...
```

2. Use the **curl** CLI command to verify that the external load balancer and its resources are operational:

   a. Verify that the cluster machine configuration API is accessible to the Kubernetes API server resource, by running the following command and observing the response:

   ```
   $ curl https://<loadbalancer_ip_address>:6443/version --insecure
   ```

   If the configuration is correct, you receive a JSON object in response:

   ```
   {
     "major": "1",
     "minor": "11+",
     "gitVersion": "v1.11.0+ad103ed",
     "gitCommit": "ad103ed",
     "gitTreeState": "clean",
     "buildDate": "2019-01-09T06:44:10Z",
     "goVersion": "go1.10.3",
     "compiler": "gc",
     "platform": "linux/amd64"
   }
   ```

   b. Verify that the cluster machine configuration API is accessible to the Machine config server resource, by running the following command and observing the output:

   ```
   $ curl -v https://<loadbalancer_ip_address>:22623/healthz --insecure
   ```

   If the configuration is correct, the output from the command shows the following response:

   ```
   HTTP/1.1 200 OK
   Content-Length: 0
   ```

   c. Verify that the controller is accessible to the Ingress Controller resource on port 80, by running the following command and observing the output:

   ```
   $ curl -I -L -H "Host: console-openshift-console.apps.<cluster_name>.<base_domain>"
   http://<load_balancer_front_end_IP_address>
   ```

   If the configuration is correct, the output from the command shows the following response:

   ```
   HTTP/1.1 302 Found
   content-length: 0
   location: https://console-openshift-console.apps.ocp4.private.opequon.net/
   cache-control: no-cache
   ```

   d. Verify that the controller is accessible to the Ingress Controller resource on port 443, by running the following command and observing the output:

```
$ curl -I -L --insecure --resolve console-openshift-console.apps.<cluster_name>.
<base_domain>:443:<Load Balancer Front End IP Address> https://console-openshift-
console.apps.<cluster_name>.<base_domain>
```

If the configuration is correct, the output from the command shows the following response:

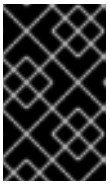
```
HTTP/1.1 200 OK
referrer-policy: strict-origin-when-cross-origin
set-cookie: csrf-
token=UlYWOyQ62LWjw2h003xtYSKlh1a0Py2hhctw0WmV2YEdhJjFyQwWcGBsja261dG
LgaYO0nxzVErhiXt6QepA7g==; Path=/; Secure; SameSite=Lax
x-content-type-options: nosniff
x-dns-prefetch-control: off
x-frame-options: DENY
x-xss-protection: 1; mode=block
date: Wed, 04 Oct 2023 16:29:38 GMT
content-type: text/html; charset=utf-8
set-cookie:
1e2670d92730b515ce3a1bb65da45062=1bf5e9573c9a2760c964ed1659cc1673; path=/;
HttpOnly; Secure; SameSite=None
cache-control: private
```

3. Configure the DNS records for your cluster to target the front-end IP addresses of the external load balancer. You must update records to your DNS server for the cluster API and applications over the load balancer.

Examples of modified DNS records

```
<load_balancer_ip_address>  A  api.<cluster_name>.<base_domain>
A record pointing to Load Balancer Front End
```

```
<load_balancer_ip_address>  A apps.<cluster_name>.<base_domain>
A record pointing to Load Balancer Front End
```



IMPORTANT

DNS propagation might take some time for each DNS record to become available. Ensure that each DNS record propagates before validating each record.

4. Use the **curl** CLI command to verify that the external load balancer and DNS record configuration are operational:

   a. Verify that you can access the cluster API, by running the following command and observing the output:

```
$ curl https://api.<cluster_name>.<base_domain>:6443/version --insecure
```

   If the configuration is correct, you receive a JSON object in response:

```
{
  "major": "1",
  "minor": "11+",
```

```
  "gitVersion": "v1.11.0+ad103ed",
  "gitCommit": "ad103ed",
  "gitTreeState": "clean",
  "buildDate": "2019-01-09T06:44:10Z",
  "goVersion": "go1.10.3",
  "compiler": "gc",
  "platform": "linux/amd64"
  }
```

b. Verify that you can access the cluster machine configuration, by running the following command and observing the output:

```
$ curl -v https://api.<cluster_name>.<base_domain>:22623/healthz --insecure
```

If the configuration is correct, the output from the command shows the following response:

```
HTTP/1.1 200 OK
Content-Length: 0
```

c. Verify that you can access each cluster application on port, by running the following command and observing the output:

```
$ curl http://console-openshift-console.apps.<cluster_name>.<base_domain> -I -L --
insecure
```

If the configuration is correct, the output from the command shows the following response:

```
HTTP/1.1 302 Found
content-length: 0
location: https://console-openshift-console.apps.<cluster-name>.<base domain>/
cache-control: no-cacheHTTP/1.1 200 OK
referrer-policy: strict-origin-when-cross-origin
set-cookie: csrf-
token=39HoZgztDnzjJkq/JuLJMeoKNXlfiVv2YgZc09c3TBOBU4NI6kDXaJH1LdicNhN1UsQ
Wzon4Dor9GWGfopaTEQ==; Path=/; Secure
x-content-type-options: nosniff
x-dns-prefetch-control: off
x-frame-options: DENY
x-xss-protection: 1; mode=block
date: Tue, 17 Nov 2020 08:42:10 GMT
content-type: text/html; charset=utf-8
set-cookie:
1e2670d92730b515ce3a1bb65da45062=9b714eb87e93cf34853e87a92d6894be; path=/;
HttpOnly; Secure; SameSite=None
cache-control: private
```

d. Verify that you can access each cluster application on port 443, by running the following command and observing the output:

```
$ curl https://console-openshift-console.apps.<cluster_name>.<base_domain> -I -L --
insecure
```

If the configuration is correct, the output from the command shows the following response:

```
HTTP/1.1 200 OK
referrer-policy: strict-origin-when-cross-origin
set-cookie: csrf-
token=UlYWOyQ62LWjw2h003xtYSKlh1a0Py2hhctw0WmV2YEdhJjFyQwWcGBsja261dG
LgaYO0nxzVErhiXt6QepA7g==; Path=/; Secure; SameSite=Lax
x-content-type-options: nosniff
x-dns-prefetch-control: off
x-frame-options: DENY
x-xss-protection: 1; mode=block
date: Wed, 04 Oct 2023 16:29:38 GMT
content-type: text/html; charset=utf-8
set-cookie:
1e2670d92730b515ce3a1bb65da45062=1bf5e9573c9a2760c964ed1659cc1673; path=/;
HttpOnly; Secure; SameSite=None
cache-control: private
```

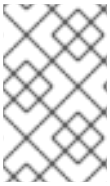
22.5.20. Next steps

- Customize your cluster.
- Configure image streams for the Cluster Samples Operator and the **must-gather** tool.
- Learn how to use Operator Lifecycle Manager (OLM) on restricted networks .
- If necessary, you can opt out of remote health reporting .
- Set up your registry and configure registry storage .

22.6. INSTALLING A CLUSTER ON VMC WITH USER-PROVISIONED INFRASTRUCTURE

In OpenShift Container Platform version 4.11, you can install a cluster on VMware vSphere infrastructure that you provision by deploying it to VMware Cloud (VMC) on AWS.

Once you configure your VMC environment for OpenShift Container Platform deployment, you use the OpenShift Container Platform installation program from the bastion management host, co-located in the VMC environment. The installation program and control plane automates the process of deploying and managing the resources needed for the OpenShift Container Platform cluster.

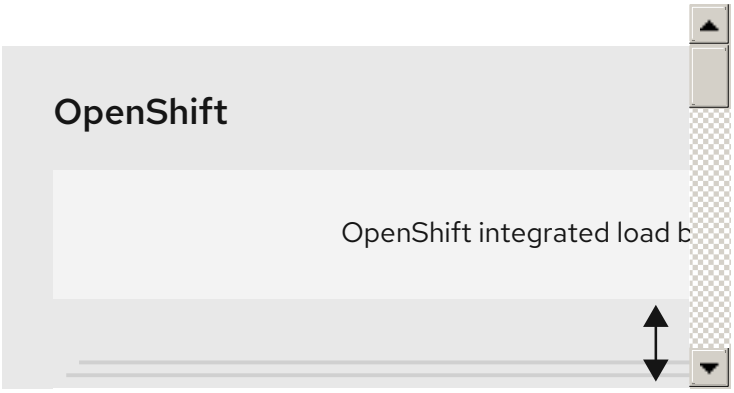


NOTE

OpenShift Container Platform supports deploying a cluster to a single VMware vCenter only. Deploying a cluster with machines/machine sets on multiple vCenters is not supported.

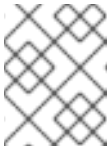
22.6.1. Setting up VMC for vSphere

You can install OpenShift Container Platform on VMware Cloud (VMC) on AWS hosted vSphere clusters to enable applications to be deployed and managed both on-premise and off-premise, across the hybrid cloud.



You must configure several options in your VMC environment prior to installing OpenShift Container Platform on VMware vSphere. Ensure your VMC environment has the following prerequisites:

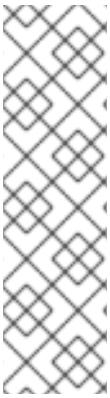
- Create a non-exclusive, DHCP-enabled, NSX-T network segment and subnet. Other virtual machines (VMs) can be hosted on the subnet, but at least eight IP addresses must be available for the OpenShift Container Platform deployment.
- Configure the following firewall rules:
    - An ANY:ANY firewall rule between the OpenShift Container Platform compute network and the internet. This is used by nodes and applications to download container images.
    - An ANY:ANY firewall rule between the installation host and the software-defined data center (SDDC) management network on port 443. This allows you to upload the Red Hat Enterprise Linux CoreOS (RHCOS) OVA during deployment.
    - An HTTPS firewall rule between the OpenShift Container Platform compute network and vCenter. This connection allows OpenShift Container Platform to communicate with vCenter for provisioning and managing nodes, persistent volume claims (PVCs), and other resources.
- You must have the following information to deploy OpenShift Container Platform:
    - The OpenShift Container Platform cluster name, such as **vmc-prod-1**.
    - The base DNS name, such as **companyname.com**.
    - If not using the default, the pod network CIDR and services network CIDR must be identified, which are set by default to **10.128.0.0/14** and **172.30.0.0/16**, respectively. These CIDRs are used for pod-to-pod and pod-to-service communication and are not accessible externally; however, they must not overlap with existing subnets in your organization.
    - The following vCenter information:
        - vCenter hostname, username, and password
        - Datacenter name, such as **SDDC-Datacenter**
        - Cluster name, such as **Cluster-1**
        - Network name
        - Datastore name, such as **WorkloadDatastore**



NOTE

It is recommended to move your vSphere cluster to the VMC **Compute-ResourcePool** resource pool after your cluster installation is finished.

- A Linux-based host deployed to VMC as a bastion.
  - The bastion host can be Red Hat Enterprise Linux (RHEL) or any another Linux-based host; it must have internet connectivity and the ability to upload an OVA to the ESXi hosts.
  - Download and install the OpenShift CLI tools to the bastion host.
    - The **openshift-install** installation program
    - The OpenShift CLI (**oc**) tool



NOTE

You cannot use the VMware NSX Container Plugin for Kubernetes (NCP), and NSX is not used as the OpenShift SDN. The version of NSX currently available with VMC is incompatible with the version of NCP certified with OpenShift Container Platform.

However, the NSX DHCP service is used for virtual machine IP management with the full-stack automated OpenShift Container Platform deployment and with nodes provisioned, either manually or automatically, by the Machine API integration with vSphere. Additionally, NSX firewall rules are created to enable access with the OpenShift Container Platform cluster and between the bastion host and the VMC vSphere hosts.

22.6.1.1. VMC Sizer tool

VMware Cloud on AWS is built on top of AWS bare metal infrastructure; this is the same bare metal infrastructure which runs AWS native services. When a VMware cloud on AWS software-defined data center (SDDC) is deployed, you consume these physical server nodes and run the VMware ESXi hypervisor in a single tenant fashion. This means the physical infrastructure is not accessible to anyone else using VMC. It is important to consider how many physical hosts you will need to host your virtual infrastructure.

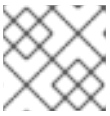
To determine this, VMware provides the VMC on AWS Sizer. With this tool, you can define the resources you intend to host on VMC:

- Types of workloads
- Total number of virtual machines
- Specification information such as:
  - Storage requirements
  - vCPUs
  - vRAM
  - Overcommit ratios

With these details, the sizer tool can generate a report, based on VMware best practices, and recommend your cluster configuration and the number of hosts you will need.

22.6.2. vSphere prerequisites

- You reviewed details about the OpenShift Container Platform installation and update processes.
- You read the documentation on selecting a cluster installation method and preparing it for users.
- You provisioned block registry storage. For more information on persistent storage, see Understanding persistent storage.
- If you use a firewall, you configured it to allow the sites that your cluster requires access to.



NOTE

Be sure to also review this site list if you are configuring a proxy.

22.6.3. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.11, you require access to the internet to install your cluster.

You must have internet access to:

- Access OpenShift Cluster Manager Hybrid Cloud Console to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access Quay.io to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.

IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

22.6.4. VMware vSphere infrastructure requirements

You must install the OpenShift Container Platform cluster on a VMware vSphere version 7 instance that meets the requirements for the components that you use.

NOTE

OpenShift Container Platform version 4.11 does not support VMware vSphere version 8.0.

You can host the VMware vSphere infrastructure on-premise or on a VMware Cloud Verified provider that meets the requirements outlined in the following table:

Table 22.49. Version requirements for vSphere virtual environments

Virtual environment product	Required version
VM hardware version	15 or later
vSphere ESXi hosts	7
vCenter host	7

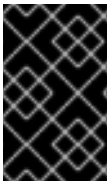
IMPORTANT

Installing a cluster on VMware vSphere version 7.0 Update 1 or earlier is now deprecated. These versions are still fully supported, but version 4.11 of OpenShift Container Platform requires vSphere virtual hardware version 15 or later. Hardware version 15 is now the default for vSphere virtual machines in OpenShift Container Platform. To update the hardware version for your vSphere nodes, see the "Updating hardware on nodes running in vSphere" article.

If your vSphere nodes are below hardware version 15 or your VMware vSphere version is earlier than 6.7.3, upgrading from OpenShift Container Platform 4.10 to OpenShift Container Platform 4.11 is not available.

Table 22.50. Minimum supported vSphere version for VMware components

Component	Minimum supported versions	Description
Hypervisor	vSphere 7 with HW version 15	This version is the minimum version that Red Hat Enterprise Linux CoreOS (RHCOS) supports. For more information about supported hardware on the latest version of Red Hat Enterprise Linux (RHEL) that is compatible with RHCOS, see Hardware on the Red Hat Customer Portal.
Storage with in-tree drivers	vSphere 7	This plugin creates vSphere storage by using the in-tree storage drivers for vSphere included in OpenShift Container Platform.



IMPORTANT

You must ensure that the time on your ESXi hosts is synchronized before you install OpenShift Container Platform. See Edit Time Configuration for a Host in the VMware documentation.

22.6.5. VMware vSphere CSI Driver Operator requirements

To install the vSphere CSI Driver Operator, the following requirements must be met:

- VMware vSphere version 7.0 Update 1 or later
- Virtual machines of hardware version 15 or later
- No third-party vSphere CSI driver already installed in the cluster

IMPORTANT

If a third-party vSphere CSI driver is present in the cluster, OpenShift Container Platform does not overwrite it. If you continue with the third-party vSphere CSI driver when upgrading to the next major version of OpenShift Container Platform, the **oc** CLI prompts you with the following message:

> VSphereCSIDriverOperatorCRUpgradeable: VMwareVSphereControllerUpgradeable: found existing unsupported csi.vsphere.vmware.com driver

The previous message informs you that Red Hat does not support the third-party vSphere CSI driver during an OpenShift Container Platform upgrade operation. You can choose to ignore this message and continue with the upgrade operation.

Additional resources

- To remove a third-party CSI driver, see Removing a third-party vSphere CSI Driver .
- To update the hardware version for your vSphere nodes, see Updating hardware on nodes running in vSphere.

22.6.6. Requirements for a cluster with user-provisioned infrastructure

For a cluster that contains user-provisioned infrastructure, you must deploy all of the required machines.

This section describes the requirements for deploying OpenShift Container Platform on user-provisioned infrastructure.

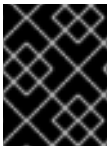
22.6.6.1. Required machines for cluster installation

The smallest OpenShift Container Platform clusters require the following hosts:

Table 22.51. Minimum required hosts

Hosts	Description
One temporary bootstrap machine	The cluster requires the bootstrap machine to deploy the OpenShift Container Platform cluster on the three control plane machines. You can remove the bootstrap machine after you install the cluster.

Hosts	Description
Three control plane machines	The control plane machines run the Kubernetes and OpenShift Container Platform services that form the control plane.
At least two compute machines, which are also known as worker machines.	The workloads requested by OpenShift Container Platform users run on the compute machines.



IMPORTANT

To maintain high availability of your cluster, use separate physical hosts for these cluster machines.

The bootstrap and control plane machines must use Red Hat Enterprise Linux CoreOS (RHCOS) as the operating system. However, the compute machines can choose between Red Hat Enterprise Linux CoreOS (RHCOS), Red Hat Enterprise Linux (RHEL) 8.6 and later.

Note that RHCOS is based on Red Hat Enterprise Linux (RHEL) 8 and inherits all of its hardware certifications and requirements. See Red Hat Enterprise Linux technology capabilities and limits .

22.6.6.2. Minimum resource requirements for cluster installation

Each cluster machine must meet the following minimum requirements:

Table 22.52. Minimum resource requirements

Machine	Operating System	vCPU [1]	Virtual RAM	Storage	IOPS [2]
Bootstrap	RHCOS	4	16 GB	100 GB	300
Control plane	RHCOS	4	16 GB	100 GB	300
Compute	RHCOS, RHEL 8.6 and later [3]	2	8 GB	100 GB	300

1. One vCPU is equivalent to one physical core when simultaneous multithreading (SMT), or hyperthreading, is not enabled. When enabled, use the following formula to calculate the corresponding ratio: (threads per core × cores) × sockets = vCPUs.

2. OpenShift Container Platform and Kubernetes are sensitive to disk performance, and faster storage is recommended, particularly for etcd on the control plane nodes which require a 10 ms p99 fsync duration. Note that on many cloud platforms, storage size and IOPS scale together, so you might need to over-allocate storage volume to obtain sufficient performance.

3. As with all user-provisioned installations, if you choose to use RHEL compute machines in your cluster, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks.

Use of RHEL 7 compute machines is deprecated and has been removed in OpenShift Container Platform 4.10 and later.

If an instance type for your platform meets the minimum requirements for cluster machines, it is supported to use in OpenShift Container Platform.

22.6.6.3. Certificate signing requests management

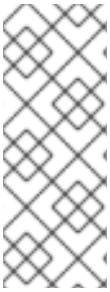
Because your cluster has limited access to automatic machine management when you use infrastructure that you provision, you must provide a mechanism for approving cluster certificate signing requests (CSRs) after installation. The **kube-controller-manager** only approves the kubelet client CSRs. The **machine-approver** cannot guarantee the validity of a serving certificate that is requested by using kubelet credentials because it cannot confirm that the correct machine issued the request. You must determine and implement a method of verifying the validity of the kubelet serving certificate requests and approving them.

22.6.6.4. Networking requirements for user-provisioned infrastructure

All the Red Hat Enterprise Linux CoreOS (RHCOS) machines require networking to be configured in **initramfs** during boot to fetch their Ignition config files.

During the initial boot, the machines require an IP address configuration that is set either through a DHCP server or statically by providing the required boot options. After a network connection is established, the machines download their Ignition config files from an HTTP or HTTPS server. The Ignition config files are then used to set the exact state of each machine. The Machine Config Operator completes more changes to the machines, such as the application of new certificates or keys, after installation.

It is recommended to use a DHCP server for long-term management of the cluster machines. Ensure that the DHCP server is configured to provide persistent IP addresses, DNS server information, and hostnames to the cluster machines.



NOTE

If a DHCP service is not available for your user-provisioned infrastructure, you can instead provide the IP networking configuration and the address of the DNS server to the nodes at RHCOS install time. These can be passed as boot arguments if you are installing from an ISO image. See the *Installing RHCOS and starting the OpenShift Container Platform bootstrap process* section for more information about static IP provisioning and advanced networking options.

The Kubernetes API server must be able to resolve the node names of the cluster machines. If the API servers and worker nodes are in different zones, you can configure a default DNS search zone to allow the API server to resolve the node names. Another supported approach is to always refer to hosts by their fully-qualified domain names in both the node objects and all DNS requests.

22.6.6.4.1. Setting the cluster node hostnames through DHCP

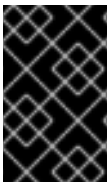
On Red Hat Enterprise Linux CoreOS (RHCOS) machines, the hostname is set through NetworkManager. By default, the machines obtain their hostname through DHCP. If the hostname is not provided by DHCP, set statically through kernel arguments, or another method, it is obtained through a reverse DNS lookup. Reverse DNS lookup occurs after the network has been initialized on a node and can take time to resolve. Other system services can start prior to this and detect the hostname as **localhost** or similar. You can avoid this by using DHCP to provide the hostname for each cluster node.

Additionally, setting the hostnames through DHCP can bypass any manual DNS record name configuration errors in environments that have a DNS split-horizon implementation.

22.6.6.4.2. Network connectivity requirements

You must configure the network connectivity between machines to allow OpenShift Container Platform cluster components to communicate. Each machine must be able to resolve the hostnames of all other machines in the cluster.

This section provides details about the ports that are required.



IMPORTANT

In connected OpenShift Container Platform environments, all nodes are required to have internet access to pull images for platform containers and provide telemetry data to Red Hat.

Table 22.53. Ports used for all-machine to all-machine communications

Protocol	Port	Description
ICMP	N/A	Network reachability tests
TCP	**1936**	Metrics
	9000-**9999**	Host level services, including the node exporter on ports **9100**-**9101** and the Cluster Version Operator on port**9099**.
	10250-**10259**	The default ports that Kubernetes reserves
	10256	openshift-sdn
UDP	**4789**	VXLAN
	6081	Geneve
	9000-**9999**	Host level services, including the node exporter on ports **9100**-**9101**.
	500	IPsec IKE packets
	4500	IPsec NAT-T packets
TCP/UDP	**30000**-**32767**	Kubernetes node port
ESP	N/A	IPsec Encapsulating Security Payload (ESP)

Table 22.54. Ports used for all-machine to control plane communications

Protocol	Port	Description
TCP	**6443**	Kubernetes API

Table 22.55. Ports used for control plane machine to control plane machine communications

Protocol	Port	Description
TCP	**2379-2380**	etcd server and peer ports

Ethernet adaptor hardware address requirements
When provisioning VMs for the cluster, the ethernet interfaces configured for each VM must use a MAC address from the VMware Organizationally Unique Identifier (OUI) allocation ranges:

- **00:05:69:00:00:00** to **00:05:69:FF:FF:FF**
- **00:0c:29:00:00:00** to **00:0c:29:FF:FF:FF**
- **00:1c:14:00:00:00** to **00:1c:14:FF:FF:FF**
- **00:50:56:00:00:00** to **00:50:56:3F:FF:FF**

If a MAC address outside the VMware OUI is used, the cluster installation will not succeed.

NTP configuration for user-provisioned infrastructure
OpenShift Container Platform clusters are configured to use a public Network Time Protocol (NTP) server by default. If you want to use a local enterprise NTP server, or if your cluster is being deployed in a disconnected network, you can configure the cluster to use a specific time server. For more information, see the documentation for *Configuring chrony time service* .

If a DHCP server provides NTP server information, the chrony time service on the Red Hat Enterprise Linux CoreOS (RHCOS) machines read the information and can sync the clock with the NTP servers.

22.6.6.5. User-provisioned DNS requirements

In OpenShift Container Platform deployments, DNS name resolution is required for the following components:

- The Kubernetes API
- The OpenShift Container Platform application wildcard
- The bootstrap, control plane, and compute machines

Reverse DNS resolution is also required for the Kubernetes API, the bootstrap machine, the control plane machines, and the compute machines.

DNS A/AAAA or CNAME records are used for name resolution and PTR records are used for reverse name resolution. The reverse records are important because Red Hat Enterprise Linux CoreOS (RHCOS) uses the reverse records to set the hostnames for all the nodes, unless the hostnames are provided by DHCP. Additionally, the reverse records are used to generate the certificate signing requests (CSR) that OpenShift Container Platform needs to operate.

NOTE

It is recommended to use a DHCP server to provide the hostnames to each cluster node. See the *DHCP recommendations for user-provisioned infrastructure* section for more information.

The following DNS records are required for a user-provisioned OpenShift Container Platform cluster and they must be in place before installation. In each record, **<cluster_name>** is the cluster name and **<base_domain>** is the base domain that you specify in the **install-config.yaml** file. A complete DNS record takes the form: **<component>.<cluster_name>.<base_domain>.**.

Table 22.56. Required DNS records

Component	Record	Description
Kubernetes API	**api.<cluster_name>.<base_domain>.**	A DNS A/AAAA or CNAME record, and a DNS PTR record, to identify the API load balancer. These records must be resolvable by both clients external to the cluster and from all the nodes within the cluster.
	api-int.<cluster_name>.<base_domain>.	A DNS A/AAAA or CNAME record, and a DNS PTR record, to internally identify the API load balancer. These records must be resolvable from all the nodes within the cluster.  IMPORTANT The API server must be able to resolve the worker nodes by the hostnames that are recorded in Kubernetes. If the API server cannot resolve the node names, then proxied API calls can fail, and you cannot retrieve logs from pods.
Routes	***.apps.<cluster_name>.<base_domain>.**	A wildcard DNS A/AAAA or CNAME record that refers to the application ingress load balancer. The application ingress load balancer targets the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default. These records must be resolvable by both clients external to the cluster and from all the nodes within the cluster. For example, **console-openshift-console.apps.<cluster_name>.<base_domain>** is used as a wildcard route to the OpenShift Container Platform console.
Bootstrap machine	**bootstrap.<cluster_name>.<base_domain>.**	A DNS A/AAAA or CNAME record, and a DNS PTR record, to identify the bootstrap machine. These records must be resolvable by the nodes within the cluster.

Component	Record	Description
Control plane machines	**<master><n>. <cluster_name>. <base_domain>.**	DNS A/AAAA or CNAME records and DNS PTR records to identify each machine for the control plane nodes. These records must be resolvable by the nodes within the cluster.
Compute machines	**<worker><n>. <cluster_name>. <base_domain>.**	DNS A/AAAA or CNAME records and DNS PTR records to identify each machine for the worker nodes. These records must be resolvable by the nodes within the cluster.

NOTE

In OpenShift Container Platform 4.4 and later, you do not need to specify etcd host and SRV records in your DNS configuration.

TIP

You can use the **dig** command to verify name and reverse name resolution. See the section on *Validating DNS resolution for user-provisioned infrastructure* for detailed validation steps.

22.6.6.5.1. Example DNS configuration for user-provisioned clusters

This section provides A and PTR record configuration samples that meet the DNS requirements for deploying OpenShift Container Platform on user-provisioned infrastructure. The samples are not meant to provide advice for choosing one DNS solution over another.

In the examples, the cluster name is **ocp4** and the base domain is **example.com**.

Example DNS A record configuration for a user-provisioned cluster

The following example is a BIND zone file that shows sample A records for name resolution in a user-provisioned cluster.

Example 22.13. Sample DNS zone database

```
$TTL 1W
@ IN SOA ns1.example.com. root (
   2019070700 ; serial
   3H  ; refresh (3 hours)
   30M  ; retry (30 minutes)
   2W  ; expiry (2 weeks)
   1W )  ; minimum (1 week)
 IN NS ns1.example.com.
 IN MX 10 smtp.example.com.
;
;
ns1.example.com.  IN A 192.168.1.5
smtp.example.com.  IN A 192.168.1.5
;
helper.example.com.  IN A 192.168.1.5
```

```
helper.ocp4.example.com. IN A 192.168.1.5
;
api.ocp4.example.com.  IN A 192.168.1.5 1
api-int.ocp4.example.com. IN A 192.168.1.5 2
;
*.apps.ocp4.example.com. IN A 192.168.1.5 3
;
bootstrap.ocp4.example.com. IN A 192.168.1.96 4
;
master0.ocp4.example.com. IN A 192.168.1.97 5
master1.ocp4.example.com. IN A 192.168.1.98 6
master2.ocp4.example.com. IN A 192.168.1.99 7
;
worker0.ocp4.example.com. IN A 192.168.1.11 8
worker1.ocp4.example.com. IN A 192.168.1.7 9
;
;EOF
```

1 Provides name resolution for the Kubernetes API. The record refers to the IP address of the API load balancer.

2 Provides name resolution for the Kubernetes API. The record refers to the IP address of the API load balancer and is used for internal cluster communications.

3 Provides name resolution for the wildcard routes. The record refers to the IP address of the application ingress load balancer. The application ingress load balancer targets the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.

NOTE

In the example, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

4 Provides name resolution for the bootstrap machine.

5 6 7 Provides name resolution for the control plane machines.

8 9 Provides name resolution for the compute machines.

Example DNS PTR record configuration for a user-provisioned cluster

The following example BIND zone file shows sample PTR records for reverse name resolution in a user-provisioned cluster.

Example 22.14. Sample DNS zone database for reverse records

```
$TTL 1W
@ IN SOA ns1.example.com. root (
  2019070700 ; serial
```

```
    3H  ; refresh (3 hours)
    30M  ; retry (30 minutes)
    2W  ; expiry (2 weeks)
    1W )  ; minimum (1 week)
  IN NS ns1.example.com.
;
5.1.168.192.in-addr.arpa. IN PTR api.ocp4.example.com. 1
5.1.168.192.in-addr.arpa. IN PTR api-int.ocp4.example.com. 2
;
96.1.168.192.in-addr.arpa. IN PTR bootstrap.ocp4.example.com. 3
;
97.1.168.192.in-addr.arpa. IN PTR master0.ocp4.example.com. 4
98.1.168.192.in-addr.arpa. IN PTR master1.ocp4.example.com. 5
99.1.168.192.in-addr.arpa. IN PTR master2.ocp4.example.com. 6
;
11.1.168.192.in-addr.arpa. IN PTR worker0.ocp4.example.com. 7
7.1.168.192.in-addr.arpa. IN PTR worker1.ocp4.example.com. 8
;
;EOF
```

1 Provides reverse DNS resolution for the Kubernetes API. The PTR record refers to the record name of the API load balancer.

2 Provides reverse DNS resolution for the Kubernetes API. The PTR record refers to the record name of the API load balancer and is used for internal cluster communications.

3 Provides reverse DNS resolution for the bootstrap machine.

4 5 6 Provides reverse DNS resolution for the control plane machines.

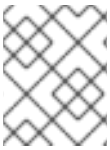
7 8 Provides reverse DNS resolution for the compute machines.

NOTE

A PTR record is not required for the OpenShift Container Platform application wildcard.

22.6.6.6. Load balancing requirements for user-provisioned infrastructure

Before you install OpenShift Container Platform, you must provision the API and application ingress load balancing infrastructure. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.



NOTE

If you want to deploy the API and application Ingress load balancers with a Red Hat Enterprise Linux (RHEL) instance, you must purchase the RHEL subscription separately.

The load balancing infrastructure must meet the following requirements:

1. **API load balancer**: Provides a common endpoint for users, both human and machine, to interact with and configure the platform. Configure the following conditions:

- Layer 4 load balancing only. This can be referred to as Raw TCP, SSL Passthrough, or SSL Bridge mode. If you use SSL Bridge mode, you must enable Server Name Indication (SNI) for the API routes.
- A stateless load balancing algorithm. The options vary based on the load balancer implementation.

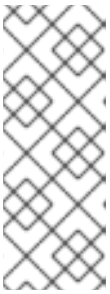
IMPORTANT

Do not configure session persistence for an API load balancer. Configuring session persistence for a Kubernetes API server might cause performance issues from excess application traffic for your OpenShift Container Platform cluster and the Kubernetes API that runs inside the cluster.

Configure the following ports on both the front and back of the load balancers:

Table 22.57. API load balancer

Port	Back-end machines (pool members)	Internal	External	Description
6443	Bootstrap and control plane. You remove the bootstrap machine from the load balancer after the bootstrap machine initializes the cluster control plane. You must configure the **/readyz** endpoint for the API server health check probe.	X	X	Kubernetes API server
22623	Bootstrap and control plane. You remove the bootstrap machine from the load balancer after the bootstrap machine initializes the cluster control plane.	X		Machine config server



NOTE

The load balancer must be configured to take a maximum of 30 seconds from the time the API server turns off the **/readyz** endpoint to the removal of the API server instance from the pool. Within the time frame after **/readyz** returns an error or becomes healthy, the endpoint must have been removed or added. Probing every 5 or 10 seconds, with two successful requests to become healthy and three to become unhealthy, are well-tested values.

2. **Application Ingress load balancer**: Provides an ingress point for application traffic flowing in from outside the cluster. A working configuration for the Ingress router is required for an OpenShift Container Platform cluster.
   Configure the following conditions:

   - Layer 4 load balancing only. This can be referred to as Raw TCP, SSL Passthrough, or SSL Bridge mode. If you use SSL Bridge mode, you must enable Server Name Indication (SNI) for the ingress routes.

- A connection-based or session-based persistence is recommended, based on the options available and types of applications that will be hosted on the platform.

TIP

If the true IP address of the client can be seen by the application Ingress load balancer, enabling source IP-based session persistence can improve performance for applications that use end-to-end TLS encryption.

Configure the following ports on both the front and back of the load balancers:

Table 22.58. Application Ingress load balancer

Port	Back-end machines (pool members)	Internal	External	Description
443	The machines that run the Ingress Controller pods, compute, or worker, by default.	X	X	HTTPS traffic
80	The machines that run the Ingress Controller pods, compute, or worker, by default.	X	X	HTTP traffic

NOTE

If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application Ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes.

22.6.6.6.1. Example load balancer configuration for user-provisioned clusters

This section provides an example API and application ingress load balancer configuration that meets the load balancing requirements for user-provisioned clusters. The sample is an **/etc/haproxy/haproxy.cfg** configuration for an HAProxy load balancer. The example is not meant to provide advice for choosing one load balancing solution over another.

In the example, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

NOTE

If you are using HAProxy as a load balancer and SELinux is set to **enforcing**, you must ensure that the HAProxy service can bind to the configured TCP port by running **setsebool -P haproxy_connect_any=1**.

Example 22.15. Sample API and application Ingress load balancer configuration

```
global
  log         127.0.0.1 local2
  pidfile     /var/run/haproxy.pid
```

```
  maxconn     4000
  daemon
defaults
  mode                    http
  log                     global
  option                  dontlognull
  option http-server-close
  option                  redispatch
  retries                 3
  timeout http-request    10s
  timeout queue           1m
  timeout connect         10s
  timeout client          1m
  timeout server          1m
  timeout http-keep-alive 10s
  timeout check           10s
  maxconn                 3000
listen api-server-6443 (1)
  bind *:6443
  mode tcp
  server bootstrap bootstrap.ocp4.example.com:6443 check inter 1s backup (2)
  server master0 master0.ocp4.example.com:6443 check inter 1s
  server master1 master1.ocp4.example.com:6443 check inter 1s
  server master2 master2.ocp4.example.com:6443 check inter 1s
listen machine-config-server-22623 (3)
  bind *:22623
  mode tcp
  option  httpchk GET /readyz HTTP/1.0
  option  log-health-checks
  balance roundrobin
  server bootstrap bootstrap.ocp4.example.com:6443 verify none check check-ssl inter 10s fall 2
rise 3 backup (4)
  server master0 master0.ocp4.example.com:6443 weight 1 verify none check check-ssl inter 10s
fall 2 rise 3
  server master1 master1.ocp4.example.com:6443 weight 1 verify none check check-ssl inter 10s
fall 2 rise 3
  server master2 master2.ocp4.example.com:6443 weight 1 verify none check check-ssl inter 10s
fall 2 rise 3
listen ingress-router-443 (5)
  bind *:443
  mode tcp
  balance source
  server worker0 worker0.ocp4.example.com:443 check inter 1s
  server worker1 worker1.ocp4.example.com:443 check inter 1s
listen ingress-router-80 (6)
  bind *:80
  mode tcp
  balance source
  server worker0 worker0.ocp4.example.com:80 check inter 1s
  server worker1 worker1.ocp4.example.com:80 check inter 1s
```

(1) Port **6443** handles the Kubernetes API traffic and points to the control plane machines.

(2) (4) The bootstrap entries must be in place before the OpenShift Container Platform cluster installation and they must be removed after the bootstrap process is complete.

3 Port **22623** handles the machine config server traffic and points to the control plane machines.

5 Port **443** handles the HTTPS traffic and points to the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.

6 Port **80** handles the HTTP traffic and points to the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.

NOTE

If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application Ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes.

TIP

If you are using HAProxy as a load balancer, you can check that the **haproxy** process is listening on ports **6443**, **22623**, **443**, and **80** by running **netstat -nltupe** on the HAProxy node.

22.6.7. Preparing the user-provisioned infrastructure

Before you install OpenShift Container Platform on user-provisioned infrastructure, you must prepare the underlying infrastructure.

This section provides details about the high-level steps required to set up your cluster infrastructure in preparation for an OpenShift Container Platform installation. This includes configuring IP networking and network connectivity for your cluster nodes, enabling the required ports through your firewall, and setting up the required DNS and load balancing infrastructure.

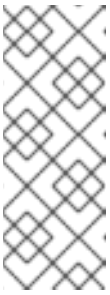
After preparation, your cluster infrastructure must meet the requirements outlined in the *Requirements for a cluster with user-provisioned infrastructure* section.

Prerequisites

- You have reviewed the OpenShift Container Platform 4.x Tested Integrations page.
- You have reviewed the infrastructure requirements detailed in the *Requirements for a cluster with user-provisioned infrastructure* section.

Procedure

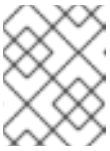
1. If you are using DHCP to provide the IP networking configuration to your cluster nodes, configure your DHCP service.
   a. Add persistent IP addresses for the nodes to your DHCP server configuration. In your configuration, match the MAC address of the relevant network interface to the intended IP address for each node.
   b. When you use DHCP to configure IP addressing for the cluster machines, the machines also obtain the DNS server information through DHCP. Define the persistent DNS server address that is used by the cluster nodes through your DHCP server configuration.



NOTE

If you are not using a DHCP service, you must provide the IP networking configuration and the address of the DNS server to the nodes at RHCOS install time. These can be passed as boot arguments if you are installing from an ISO image. See the *Installing RHCOS and starting the OpenShift Container Platform bootstrap process* section for more information about static IP provisioning and advanced networking options.

c. Define the hostnames of your cluster nodes in your DHCP server configuration. See the *Setting the cluster node hostnames through DHCP* section for details about hostname considerations.



NOTE

If you are not using a DHCP service, the cluster nodes obtain their hostname through a reverse DNS lookup.

2. Ensure that your network infrastructure provides the required network connectivity between the cluster components. See the *Networking requirements for user-provisioned infrastructure* section for details about the requirements.

3. Configure your firewall to enable the ports required for the OpenShift Container Platform cluster components to communicate. See *Networking requirements for user-provisioned infrastructure* section for details about the ports that are required.

IMPORTANT

By default, port **1936** is accessible for an OpenShift Container Platform cluster, because each control plane node needs access to this port.

Avoid using the Ingress load balancer to expose this port, because doing so might result in the exposure of sensitive information, such as statistics and metrics, related to Ingress Controllers.

4. Setup the required DNS infrastructure for your cluster.

   a. Configure DNS name resolution for the Kubernetes API, the application wildcard, the bootstrap machine, the control plane machines, and the compute machines.

   b. Configure reverse DNS resolution for the Kubernetes API, the bootstrap machine, the control plane machines, and the compute machines.
   See the *User-provisioned DNS requirements* section for more information about the OpenShift Container Platform DNS requirements.

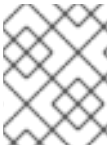
5. Validate your DNS configuration.

   a. From your installation node, run DNS lookups against the record names of the Kubernetes API, the wildcard routes, and the cluster nodes. Validate that the IP addresses in the responses correspond to the correct components.

   b. From your installation node, run reverse DNS lookups against the IP addresses of the load balancer and the cluster nodes. Validate that the record names in the responses correspond to the correct components.

See the *Validating DNS resolution for user-provisioned infrastructure* section for detailed DNS validation steps.

6. Provision the required API and application ingress load balancing infrastructure. See the *Load balancing requirements for user-provisioned infrastructure* section for more information about the requirements.



NOTE

Some load balancing solutions require the DNS name resolution for the cluster nodes to be in place before the load balancing is initialized.

22.6.8. Validating DNS resolution for user-provisioned infrastructure

You can validate your DNS configuration before installing OpenShift Container Platform on user-provisioned infrastructure.

IMPORTANT

The validation steps detailed in this section must succeed before you install your cluster.

Prerequisites

- You have configured the required DNS records for your user-provisioned infrastructure.

Procedure

1. From your installation node, run DNS lookups against the record names of the Kubernetes API, the wildcard routes, and the cluster nodes. Validate that the IP addresses contained in the responses correspond to the correct components.

   a. Perform a lookup against the Kubernetes API record name. Check that the result points to the IP address of the API load balancer:

   ```
   $ dig +noall +answer @<nameserver_ip> api.<cluster_name>.<base_domain>
   ```
   (1)

   (1) Replace **<nameserver_ip>** with the IP address of the nameserver, **<cluster_name>** with your cluster name, and **<base_domain>** with your base domain name.

   Example output

   ```
   api.ocp4.example.com.  604800 IN A 192.168.1.5
   ```

   b. Perform a lookup against the Kubernetes internal API record name. Check that the result points to the IP address of the API load balancer:

   ```
   $ dig +noall +answer @<nameserver_ip> api-int.<cluster_name>.<base_domain>
   ```

   Example output

   ```
   api-int.ocp4.example.com.  604800 IN A 192.168.1.5
   ```

c. Test an example ***.apps.<cluster_name>.<base_domain>** DNS wildcard lookup. All of the application wildcard lookups must resolve to the IP address of the application ingress load balancer:

```
$ dig +noall +answer @<nameserver_ip> random.apps.<cluster_name>.<base_domain>
```

Example output

```
random.apps.ocp4.example.com.  604800 IN A 192.168.1.5
```

NOTE

In the example outputs, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

You can replace **random** with another wildcard value. For example, you can query the route to the OpenShift Container Platform console:

```
$ dig +noall +answer @<nameserver_ip> console-openshift-console.apps.
<cluster_name>.<base_domain>
```

Example output

```
console-openshift-console.apps.ocp4.example.com. 604800 IN A 192.168.1.5
```

d. Run a lookup against the bootstrap DNS record name. Check that the result points to the IP address of the bootstrap node:

```
$ dig +noall +answer @<nameserver_ip> bootstrap.<cluster_name>.<base_domain>
```

Example output

```
bootstrap.ocp4.example.com.  604800 IN A 192.168.1.96
```

e. Use this method to perform lookups against the DNS record names for the control plane and compute nodes. Check that the results correspond to the IP addresses of each node.

2. From your installation node, run reverse DNS lookups against the IP addresses of the load balancer and the cluster nodes. Validate that the record names contained in the responses correspond to the correct components.

a. Perform a reverse lookup against the IP address of the API load balancer. Check that the response includes the record names for the Kubernetes API and the Kubernetes internal API:

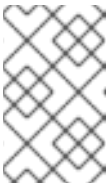
```
$ dig +noall +answer @<nameserver_ip> -x 192.168.1.5
```

Example output

```
5.1.168.192.in-addr.arpa. 604800 IN PTR api-int.ocp4.example.com. 1
5.1.168.192.in-addr.arpa. 604800 IN PTR api.ocp4.example.com. 2
```

1 Provides the record name for the Kubernetes internal API.

2 Provides the record name for the Kubernetes API.



NOTE

A PTR record is not required for the OpenShift Container Platform application wildcard. No validation step is needed for reverse DNS resolution against the IP address of the application ingress load balancer.

b. Perform a reverse lookup against the IP address of the bootstrap node. Check that the result points to the DNS record name of the bootstrap node:

```
$ dig +noall +answer @<nameserver_ip> -x 192.168.1.96
```

Example output

```
96.1.168.192.in-addr.arpa. 604800 IN PTR bootstrap.ocp4.example.com.
```

c. Use this method to perform reverse lookups against the IP addresses for the control plane and compute nodes. Check that the results correspond to the DNS record names of each node.

22.6.9. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the **~/.ssh/authorized_keys** list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The **./openshift-install gather** command also requires the SSH public key to be in place on the cluster nodes.

IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.

NOTE

You must use a local key, not one that you configured with platform-specific approaches such as AWS key pairs.

Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N '' -f <path>/<file_name> 1
```

1 Specify the path and file name, such as ~/**.ssh/id_ed25519**, of the new SSH key. If you have an existing key pair, ensure your public key is in the your ~/**.ssh** directory.

NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS validated or Modules In Process cryptographic libraries on the **x86_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

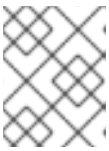
2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the ~/**.ssh/id_ed25519.pub** public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the **./openshift-install gather** command.



NOTE

On some distributions, default SSH private key identities such as ~/**.ssh/id_rsa** and ~/**.ssh/id_dsa** are managed automatically.

a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

Example output

```
Agent pid 31874
```

NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

1 Specify the path and file name for your SSH private key, such as **~/.ssh/id_ed25519**

Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program. If you install a cluster on infrastructure that you provision, you must provide the key to the installation program.

22.6.10. Obtaining the installation program

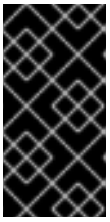
Before you install OpenShift Container Platform, download the installation file on a local computer.

Prerequisites

- You have a computer that runs Linux or macOS, with 500 MB of local disk space.

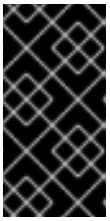
Procedure

1. Access the Infrastructure Provider page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program that corresponds with your host operating system and architecture, and place the file in the directory where you will store the installation configuration files.



IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.



IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation pull secret from the Red Hat OpenShift Cluster Manager . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

22.6.11. Manually creating the installation configuration file

For user-provisioned installations of OpenShift Container Platform, you manually generate your installation configuration file.

IMPORTANT

The Cluster Cloud Controller Manager Operator performs a connectivity check on a provided hostname or IP address. Ensure that you specify a hostname or an IP address to a reachable vCenter server. If you provide metadata to a non-existent vCenter server, installation of the cluster fails at the bootstrap stage.

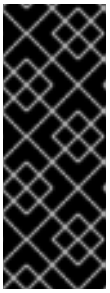
Prerequisites

- You have an SSH public key on your local machine to provide to the installation program. The key will be used for SSH authentication onto your cluster nodes for debugging and disaster recovery.
- You have obtained the OpenShift Container Platform installation program and the pull secret for your cluster.
- Obtain the **imageContentSources** section from the output of the command to mirror the repository.
- Obtain the contents of the certificate for your mirror registry.

Procedure

1. Create an installation directory to store your required installation assets in:

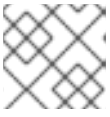
```
$ mkdir <installation_directory>
```



IMPORTANT

You must create a directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

2. Customize the sample **install-config.yaml** file template that is provided and save it in the **<installation_directory>**.



NOTE

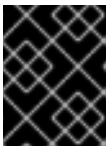
You must name this configuration file **install-config.yaml**.

- Unless you use a registry that RHCOS trusts by default, such as **docker.io**, you must provide the contents of the certificate for your mirror repository in the **additionalTrustBundle** section. In most cases, you must provide the certificate for your mirror.
- You must include the **imageContentSources** section from the output of the command to mirror the repository.

NOTE

For some platform types, you can alternatively run **./openshift-install create install-config --dir <installation_directory>** to generate an **install-config.yaml** file. You can provide details about your cluster configuration at the prompts.

3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.



IMPORTANT

The **install-config.yaml** file is consumed during the next step of the installation process. You must back it up now.

22.6.11.1. Sample install-config.yaml file for VMware vSphere

You can customize the **install-config.yaml** file to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.

```
apiVersion: v1
baseDomain: example.com (1)
compute: (2)
  name: worker
  replicas: 0 (3)
controlPlane: (4)
  name: master
  replicas: 3 (5)
metadata:
  name: test (6)
platform:
  vsphere:
    vcenter: your.vcenter.server (7)
    username: username (8)
    password: password (9)
    datacenter: datacenter (10)
    defaultDatastore: datastore (11)
    folder: "/<datacenter_name>/vm/<folder_name>/<subfolder_name>" (12)
    resourcePool: "/<datacenter_name>/host/<cluster_name>/Resources/<resource_pool_name>" (13)
    diskType: thin (14)
fips: false (15)
pullSecret: '{"auths": ...}' (16)
sshKey: 'ssh-ed25519 AAAA...' (17)
```

(1) The base domain of the cluster. All DNS records must be sub-domains of this base and include the cluster name.

2 4 The **controlPlane** section is a single mapping, but the compute section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section

3 You must set the value of the **replicas** parameter to **0**. This parameter controls the number of workers that the cluster creates and manages for you, which are functions that the cluster does not perform when you use user-provisioned infrastructure. You must manually deploy worker machines for the cluster to use before you finish installing OpenShift Container Platform.

5 The number of control plane machines that you add to the cluster. Because the cluster uses this values as the number of etcd endpoints in the cluster, the value must match the number of control plane machines that you deploy.

6 The cluster name that you specified in your DNS records.

7 The fully-qualified hostname or IP address of the vCenter server.

IMPORTANT

The Cluster Cloud Controller Manager Operator performs a connectivity check on a provided hostname or IP address. Ensure that you specify a hostname or an IP address to a reachable vCenter server. If you provide metadata to a non-existent vCenter server, installation of the cluster fails at the bootstrap stage.

8 The name of the user for accessing the server.

9 The password associated with the vSphere user.

10 The vSphere datacenter.

11 The default vSphere datastore to use.

12 Optional parameter: For installer-provisioned infrastructure, the absolute path of an existing folder where the installation program creates the virtual machines, for example, **/<datacenter_name>/vm/<folder_name>/<subfolder_name>**. If you do not provide this value, the installation program creates a top-level folder in the datacenter virtual machine folder that is named with the infrastructure ID. If you are providing the infrastructure for the cluster and you do not want to use the default **StorageClass** object, named **thin**, you can omit the **folder** parameter from the **install-config.yaml** file.

13 Optional parameter: For installer-provisioned infrastructure, the absolute path of an existing folder where the installation program creates the virtual machines, for example, **/<datacenter_name>/vm/<folder_name>/<subfolder_name>**. If you do not provide this value, the installation program creates a top-level folder in the datacenter virtual machine folder that is named with the infrastructure ID. If you are providing the infrastructure for the cluster, omit this parameter.

14 The vSphere disk provisioning method.

15 Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.

IMPORTANT

To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.

16 The pull secret that you obtained from OpenShift Cluster Manager Hybrid Cloud Console . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

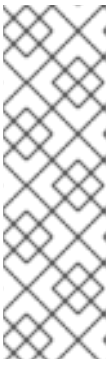
17 The public portion of the default SSH key for the **core** user in Red Hat Enterprise Linux CoreOS (RHCOS).

22.6.11.2. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.



NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
```

```
additionalTrustBundle: | 4
  -----BEGIN CERTIFICATE-----
  <MY_TRUSTED_CA_CERT>
  -----END CERTIFICATE-----
```

1. A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
2. A proxy URL to use for creating HTTPS connections outside the cluster.
3. A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use * to bypass the proxy for all destinations. You must include vCenter's IP address and the IP range that you use for its machines.
4. If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace that contains one or more additional CA certificates that are required for proxying HTTPS connections. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges these contents with the Red Hat Enterprise Linux CoreOS (RHCOS) trust bundle, and this config map is referenced in the **trustedCA** field of the **Proxy** object. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.

NOTE

The installation program does not support the proxy **readinessEndpoints** field.

NOTE

If the installer times out, restart and then complete the deployment by using the **wait-for** command of the installer. For example:

```
$ ./openshift-install wait-for install-complete --log-level debug
```

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.

NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

22.6.12. Creating the Kubernetes manifest and Ignition config files

Because you must modify some cluster definition files and manually start the cluster machines, you must generate the Kubernetes manifest and Ignition config files that the cluster needs to configure the machines.

The installation configuration file transforms into the Kubernetes manifests. The manifests wrap into the Ignition configuration files, which are later used to configure the cluster machines.

IMPORTANT

- The Ignition config files that the OpenShift Container Platform installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

Prerequisites

- You obtained the OpenShift Container Platform installation program.
- You created the **install-config.yaml** installation configuration file.

Procedure

1. Change to the directory that contains the OpenShift Container Platform installation program and generate the Kubernetes manifests for the cluster:

```
$ ./openshift-install create manifests --dir <installation_directory> 1
```

1 For **<installation_directory>**, specify the installation directory that contains the **install-config.yaml** file you created.

2. Remove the Kubernetes manifest files that define the control plane machines and compute machine sets:

```
$ rm -f openshift/99_openshift-cluster-api_master-machines-*.yaml openshift/99_openshift-cluster-api_worker-machineset-*.yaml
```

Because you create and manage these resources yourself, you do not have to initialize them.

- You can preserve the machine set files to create compute machines by using the machine API, but you must update references to them to match your environment.

3. Check that the **mastersSchedulable** parameter in the **<installation_directory>/manifests/cluster-scheduler-02-config.yml** Kubernetes manifest file is set to **false**. This setting prevents pods from being scheduled on the control plane machines:

   a. Open the **<installation_directory>/manifests/cluster-scheduler-02-config.yml** file.

   b. Locate the **mastersSchedulable** parameter and ensure that it is set to **false**.

c. Save and exit the file.

4. To create the Ignition configuration files, run the following command from the directory that contains the installation program:

```
$ ./openshift-install create ignition-configs --dir <installation_directory> 1
```

1 For **<installation_directory>**, specify the same installation directory.

Ignition config files are created for the bootstrap, control plane, and compute nodes in the installation directory. The **kubeadmin-password** and **kubeconfig** files are created in the **./<installation_directory>/auth** directory:

```
.
├── auth
│   ├── kubeadmin-password
│   └── kubeconfig
├── bootstrap.ign
├── master.ign
├── metadata.json
└── worker.ign
```

22.6.13. Extracting the infrastructure name

The Ignition config files contain a unique cluster identifier that you can use to uniquely identify your cluster in VMware Cloud on AWS. If you plan to use the cluster identifier as the name of your virtual machine folder, you must extract it.

Prerequisites

- You obtained the OpenShift Container Platform installation program and the pull secret for your cluster.
- You generated the Ignition config files for your cluster.
- You installed the **jq** package.

Procedure

- To extract and view the infrastructure name from the Ignition config file metadata, run the following command:

```
$ jq -r .infraID <installation_directory>/metadata.json 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

Example output

```
openshift-vw9j6 1
```

1 The output of this command is your cluster name and a random string.

22.6.14. Installing RHCOS and starting the OpenShift Container Platform bootstrap process

To install OpenShift Container Platform on user-provisioned infrastructure on VMware vSphere, you must install Red Hat Enterprise Linux CoreOS (RHCOS) on vSphere hosts. When you install RHCOS, you must provide the Ignition config file that was generated by the OpenShift Container Platform installation program for the type of machine you are installing. If you have configured suitable networking, DNS, and load balancing infrastructure, the OpenShift Container Platform bootstrap process begins automatically after the RHCOS machines have rebooted.

Prerequisites

- You have obtained the Ignition config files for your cluster.
- You have access to an HTTP server that you can access from your computer and that the machines that you create can access.
- You have created a vSphere cluster.

Procedure

1. Upload the bootstrap Ignition config file, which is named **<installation_directory>/bootstrap.ign**, that the installation program created to your HTTP server. Note the URL of this file.
2. Save the following secondary Ignition config file for your bootstrap node to your computer as **<installation_directory>/merge-bootstrap.ign**:

```
{
  "ignition": {
    "config": {
      "merge": [
        {
          "source": "<bootstrap_ignition_config_url>", 1
          "verification": {}
        }
      ]
    },
    "timeouts": {},
    "version": "3.2.0"
  },
  "networkd": {},
  "passwd": {},
  "storage": {},
  "systemd": {}
}
```

1 Specify the URL of the bootstrap Ignition config file that you hosted.

When you create the virtual machine (VM) for the bootstrap machine, you use this Ignition config file.

3. Locate the following Ignition config files that the installation program created:

   - **<installation_directory>/master.ign**
   - **<installation_directory>/worker.ign**
   - **<installation_directory>/merge-bootstrap.ign**

4. Convert the Ignition config files to Base64 encoding. Later in this procedure, you must add these files to the extra configuration parameter **guestinfo.ignition.config.data** in your VM. For example, if you use a Linux operating system, you can use the **base64** command to encode the files.

```
$ base64 -w0 <installation_directory>/master.ign > <installation_directory>/master.64
```

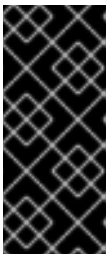
```
$ base64 -w0 <installation_directory>/worker.ign > <installation_directory>/worker.64
```

```
$ base64 -w0 <installation_directory>/merge-bootstrap.ign > <installation_directory>/merge-bootstrap.64
```

IMPORTANT

If you plan to add more compute machines to your cluster after you finish installation, do not delete these files.

5. Obtain the RHCOS OVA image. Images are available from the RHCOS image mirror page.



IMPORTANT

The RHCOS images might not change with every release of OpenShift Container Platform. You must download an image with the highest version that is less than or equal to the OpenShift Container Platform version that you install. Use the image version that matches your OpenShift Container Platform version if it is available.

   The filename contains the OpenShift Container Platform version number in the format **rhcos-vmware.<architecture>.ova**.

6. In the vSphere Client, create a folder in your datacenter to store your VMs.

   a. Click the **VMs and Templates** view.

   b. Right-click the name of your datacenter.

   c. Click **New Folder → New VM and Template Folder**.

   d. In the window that is displayed, enter the folder name. If you did not specify an existing folder in the **install-config.yaml** file, then create a folder with the same name as the infrastructure ID. You use this folder name so vCenter dynamically provisions storage in the appropriate location for its Workspace configuration.

7. In the vSphere Client, create a template for the OVA image and then clone the template as needed.

NOTE

In the following steps, you create a template and then clone the template for all of your cluster machines. You then provide the location for the Ignition config file for that cloned machine type when you provision the VMs.

a. From the **Hosts and Clusters** tab, right-click your cluster name and select **Deploy OVF Template**.

b. On the **Select an OVF** tab, specify the name of the RHCOS OVA file that you downloaded.

c. On the **Select a name and folder** tab, set a **Virtual machine name** for your template, such as **Template-RHCOS**. Click the name of your vSphere cluster and select the folder you created in the previous step.

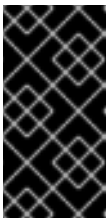
d. On the **Select a compute resource** tab, click the name of your vSphere cluster.

e. On the **Select storage** tab, configure the storage options for your VM.

- Select **Thin Provision** or **Thick Provision**, based on your storage preferences.
- Select the datastore that you specified in your **install-config.yaml** file.

f. On the **Select network** tab, specify the network that you configured for the cluster, if available.

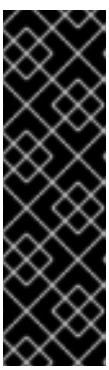
g. When creating the OVF template, do not specify values on the **Customize template** tab or configure the template any further.



IMPORTANT

Do not start the original VM template. The VM template must remain off and must be cloned for new RHCOS machines. Starting the VM template configures the VM template as a VM on the platform, which prevents it from being used as a template that machine sets can apply configurations to.

8. Optional: Update the configured virtual hardware version in the VM template, if necessary. Follow Upgrading a virtual machine to the latest hardware version in the VMware documentation for more information.



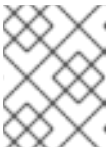
IMPORTANT

It is recommended that you update the hardware version of the VM template to version 15 before creating VMs from it, if necessary. Using hardware version 13 for your cluster nodes running on vSphere is now deprecated. If your imported template defaults to hardware version 13, you must ensure that your ESXi host is on 6.7U3 or later before upgrading the VM template to hardware version 15. If your vSphere version is less than 6.7U3, you can skip this upgrade step; however, a future version of OpenShift Container Platform is scheduled to remove support for hardware version 13 and vSphere versions less than 6.7U3.

9. After the template deploys, deploy a VM for a machine in the cluster.

a. Right-click the template name and click **Clone → Clone to Virtual Machine**

b. On the **Select a name and folder** tab, specify a name for the VM. You might include the machine type in the name, such as **control-plane-0** or **compute-1**.



NOTE

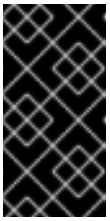
Ensure that all virtual machine names across a vSphere installation are unique.

c. On the **Select a name and folder** tab, select the name of the folder that you created for the cluster.

d. On the **Select a compute resource** tab, select the name of a host in your datacenter.

e. On the **Select clone options**, select **Customize this virtual machine's hardware**.

f. Optional: On the **Customize hardware** tab, click **VM Options → Advanced**.



IMPORTANT

The following configuration suggestions are for example purposes only. As a cluster administrator, you must configure resources according to the resource demands placed on your cluster. To best manage cluster resources, consider creating a resource pool from the cluster's root resource pool.

- Override default DHCP networking in vSphere. To enable static IP networking:
  - Set your static IP configuration:

```
$ export IPCFG="ip=<ip>::<gateway>:<netmask>:<hostname>:<iface>:none
nameserver=srv1 [nameserver=srv2 [nameserver=srv3 [...]]]"
```

Example command

```
$ export IPCFG="ip=192.168.100.101::192.168.100.254:255.255.255.0:::none
nameserver=8.8.8.8"
```

- Click **Edit Configuration**, and on the **Configuration Parameters** window, search the list of available parameters for steal clock accounting (**stealclock.enable**). Set the parameter to the value of **TRUE**. Enabling steal clock accounting can help with troubleshooting cluster issues.
- Click **Add Configuration Params**. Define the following parameter names and values:
  - **disk.EnableUUID**: Specify **TRUE**.
  - **stealclock.enable**: If this parameter was not defined, add it and specify **TRUE**.
  - Create a child resource pool from the cluster's root resource pool. Perform resource allocation in this child resource pool.

g. In the **Virtual Hardware** panel of the **Customize hardware** tab, modify the specified values as required. Ensure that the amount of RAM, CPU, and disk storage meets the minimum requirements for the machine type.

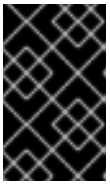
h. Complete the configuration and power on the VM.

i. Check the console output to verify that Ignition ran.

Example command

```
Ignition: ran on 2022/03/14 14:48:33 UTC (this boot)
Ignition: user-provided config was applied
```

10. Create the rest of the machines for your cluster by following the preceding steps for each machine.



IMPORTANT

You must create the bootstrap and control plane machines at this time. Because some pods are deployed on compute machines by default, also create at least two compute machines before you install the cluster.

22.6.15. Adding more compute machines to a cluster in vSphere

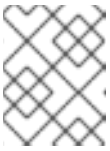
You can add more compute machines to a user-provisioned OpenShift Container Platform cluster on VMware vSphere.

Prerequisites

- Obtain the base64-encoded Ignition file for your compute machines.
- You have access to the vSphere template that you created for your cluster.

Procedure

1. After the template deploys, deploy a VM for a machine in the cluster.
   a. Right-click the template's name and click **Clone → Clone to Virtual Machine**
   b. On the **Select a name and folder** tab, specify a name for the VM. You might include the machine type in the name, such as **compute-1**.



NOTE

Ensure that all virtual machine names across a vSphere installation are unique.

   c. On the **Select a name and folder** tab, select the name of the folder that you created for the cluster.
   d. On the **Select a compute resource** tab, select the name of a host in your datacenter.
   e. On the **Select clone options**, select **Customize this virtual machine's hardware**.
   f. On the **Customize hardware** tab, click **VM Options → Advanced**.
      - Click **Edit Configuration**, and on the **Configuration Parameters** window, click **Add Configuration Params**. Define the following parameter names and values:

- **guestinfo.ignition.config.data**: Paste the contents of the base64-encoded compute Ignition config file for this machine type.
- **guestinfo.ignition.config.data.encoding**: Specify **base64**.
- **disk.EnableUUID**: Specify **TRUE**.

g. In the **Virtual Hardware** panel of the **Customize hardware** tab, modify the specified values as required. Ensure that the amount of RAM, CPU, and disk storage meets the minimum requirements for the machine type. Also, make sure to select the correct network under **Add network adapter** if there are multiple networks available.

h. Complete the configuration and power on the VM.

2. Continue to create more compute machines for your cluster.

22.6.16. Disk partitioning

In most cases, data partitions are originally created by installing RHCOS, rather than by installing another operating system. In such cases, the OpenShift Container Platform installer should be allowed to configure your disk partitions.

However, there are two cases where you might want to intervene to override the default partitioning when installing an OpenShift Container Platform node:

- Create separate partitions: For greenfield installations on an empty disk, you might want to add separate storage to a partition. This is officially supported for making **/var** or a subdirectory of **/var**, such as **/var/lib/etcd**, a separate partition, but not both.

IMPORTANT

For disk sizes larger than 100GB, and especially disk sizes larger than 1TB, create a separate **/var** partition. See "Creating a separate **/var** partition" and this Red Hat Knowledgebase article for more information.

IMPORTANT

Kubernetes supports only two file system partitions. If you add more than one partition to the original configuration, Kubernetes cannot monitor all of them.

- Retain existing partitions: For a brownfield installation where you are reinstalling OpenShift Container Platform on an existing node and want to retain data partitions installed from your previous operating system, there are both boot arguments and options to **coreos-installer** that allow you to retain existing data partitions.

Creating a separate /var partition

In general, disk partitioning for OpenShift Container Platform should be left to the installer. However, there are cases where you might want to create separate partitions in a part of the filesystem that you expect to grow.

OpenShift Container Platform supports the addition of a single partition to attach storage to either the **/var** partition or a subdirectory of **/var**. For example:

- **/var/lib/containers**: Holds container-related content that can grow as more images and containers are added to a system.

- **/var/lib/etcd**: Holds data that you might want to keep separate for purposes such as performance optimization of etcd storage.
- **/var**: Holds data that you might want to keep separate for purposes such as auditing.

IMPORTANT

For disk sizes larger than 100GB, and especially larger than 1TB, create a separate **/var** partition.

Storing the contents of a **/var** directory separately makes it easier to grow storage for those areas as needed and reinstall OpenShift Container Platform at a later date and keep that data intact. With this method, you will not have to pull all your containers again, nor will you have to copy massive log files when you update systems.

Because **/var** must be in place before a fresh installation of Red Hat Enterprise Linux CoreOS (RHCOS), the following procedure sets up the separate **/var** partition by creating a machine config manifest that is inserted during the **openshift-install** preparation phases of an OpenShift Container Platform installation.

Procedure

1. Create a directory to hold the OpenShift Container Platform installation files:

```
$ mkdir $HOME/clusterconfig
```

2. Run **openshift-install** to create a set of files in the **manifest** and **openshift** subdirectories. Answer the system questions as you are prompted:

```
$ openshift-install create manifests --dir $HOME/clusterconfig
? SSH Public Key ...
$ ls $HOME/clusterconfig/openshift/
99_kubeadmin-password-secret.yaml
99_openshift-cluster-api_master-machines-0.yaml
99_openshift-cluster-api_master-machines-1.yaml
99_openshift-cluster-api_master-machines-2.yaml
...
```

3. Create a Butane config that configures the additional partition. For example, name the file **$HOME/clusterconfig/98-var-partition.bu**, change the disk device name to the name of the storage device on the **worker** systems, and set the storage size as appropriate. This example places the **/var** directory on a separate partition:

```
variant: openshift
version: 4.11.0
metadata:
  labels:
    machineconfiguration.openshift.io/role: worker
  name: 98-var-partition
storage:
  disks:
  - device: /dev/<device_name> 1
    partitions:
    - label: var
```

```
    start_mib: <partition_start_offset> 2
    size_mib: <partition_size> 3
filesystems:
  - device: /dev/disk/by-partlabel/var
    path: /var
    format: xfs
    mount_options: [defaults, prjquota] 4
    with_mount_unit: true
```

1 The storage device name of the disk that you want to partition.

2 When adding a data partition to the boot disk, a minimum value of 25000 mebibytes is recommended. The root file system is automatically resized to fill all available space up to the specified offset. If no value is specified, or if the specified value is smaller than the recommended minimum, the resulting root file system will be too small, and future reinstalls of RHCOS might overwrite the beginning of the data partition.

3 The size of the data partition in mebibytes.

4 The **prjquota** mount option must be enabled for filesystems used for container storage.

NOTE

When creating a separate **/var** partition, you cannot use different instance types for worker nodes, if the different instance types do not have the same device name.

4. Create a manifest from the Butane config and save it to the **clusterconfig/openshift** directory. For example, run the following command:

```
$ butane $HOME/clusterconfig/98-var-partition.bu -o $HOME/clusterconfig/openshift/98-var-partition.yaml
```

5. Run **openshift-install** again to create Ignition configs from a set of files in the **manifest** and **openshift** subdirectories:

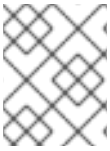
```
$ openshift-install create ignition-configs --dir $HOME/clusterconfig
$ ls $HOME/clusterconfig/
auth  bootstrap.ign  master.ign  metadata.json  worker.ign
```

Now you can use the Ignition config files as input to the vSphere installation procedures to install Red Hat Enterprise Linux CoreOS (RHCOS) systems.

22.6.17. Updating the bootloader using bootupd

To update the bootloader by using **bootupd**, you must either install **bootupd** on RHCOS machines manually or provide a machine config with the enabled **systemd** unit. Unlike **grubby** or other bootloader tools, **bootupd** does not manage kernel space configuration such as passing kernel arguments.

After you have installed **bootupd**, you can manage it remotely from the OpenShift Container Platform cluster.



NOTE

It is recommended that you use **bootupd** only on bare metal or virtualized hypervisor installations, such as for protection against the BootHole vulnerability.

Manual install method

You can manually install **bootupd** by using the **bootctl** command-line tool.

1. Inspect the system status:

```
# bootupctl status
```

Example output for x86_64

```
Component EFI
  Installed: grub2-efi-x64-1:2.04-31.fc33.x86_64,shim-x64-15-8.x86_64
  Update: At latest version
```

Example output for aarch64

```
Component EFI
  Installed: grub2-efi-aa64-1:2.02-99.el8_4.1.aarch64,shim-aa64-15.4-2.el8_1.aarch64
  Update: At latest version
```

2. RHCOS images created without **bootupd** installed on them require an explicit adoption phase. If the system status is **Adoptable**, perform the adoption:

```
# bootupctl adopt-and-update
```

Example output

```
Updated: grub2-efi-x64-1:2.04-31.fc33.x86_64,shim-x64-15-8.x86_64
```

3. If an update is available, apply the update so that the changes take effect on the next reboot:

```
# bootupctl update
```

Example output

```
Updated: grub2-efi-x64-1:2.04-31.fc33.x86_64,shim-x64-15-8.x86_64
```

Machine config method

Another way to enable **bootupd** is by providing a machine config.

- Provide a machine config file with the enabled **systemd** unit, as shown in the following example:

Example output

```
variant: rhcos
version: 1.1.0
```

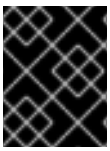
```
systemd:
  units:
    - name: custom-bootupd-auto.service
      enabled: true
      contents: |
        [Unit]
        Description=Bootupd automatic update

        [Service]
        ExecStart=/usr/bin/bootupctl update
        RemainAfterExit=yes

        [Install]
        WantedBy=multi-user.target
```

22.6.18. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.



IMPORTANT

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.11. Download and install the new version of **oc**.

Installing the OpenShift CLI on Linux

You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the architecture in the **Product Variant** drop-down menu.
3. Select the appropriate version in the **Version** drop-down menu.
4. Click **Download Now** next to the **OpenShift v4.11 Linux Client** entry and save the file.
5. Unpack the archive:

   ```
   $ tar xvf <file>
   ```

6. Place the **oc** binary in a directory that is on your **PATH**.
   To check your **PATH**, execute the following command:

   ```
   $ echo $PATH
   ```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

  ```
  $ oc <command>
  ```

Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.
   To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
C:\> oc <command>
```

Installing the OpenShift CLI on macOS

You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 macOS Client** entry and save the file.

NOTE

For macOS arm64, choose the **OpenShift v4.11 macOS arm64 Client** entry.

4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your PATH.
   To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

22.6.19. Waiting for the bootstrap process to complete

The OpenShift Container Platform bootstrap process begins after the cluster nodes first boot into the persistent RHCOS environment that has been installed to disk. The configuration information provided through the Ignition config files is used to initialize the bootstrap process and install OpenShift Container Platform on the machines. You must wait for the bootstrap process to complete.

Prerequisites

- You have created the Ignition config files for your cluster.
- You have configured suitable network, DNS and load balancing infrastructure.
- You have obtained the installation program and generated the Ignition config files for your cluster.
- You installed RHCOS on your cluster machines and provided the Ignition config files that the OpenShift Container Platform installation program generated.
- Your machines have direct internet access or have an HTTP or HTTPS proxy available.

Procedure

1. Monitor the bootstrap process:

```
$ ./openshift-install --dir <installation_directory> wait-for bootstrap-complete \ 1
    --log-level=info 2
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

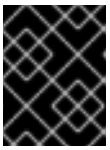
2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

Example output

```
INFO Waiting up to 30m0s for the Kubernetes API at https://api.test.example.com:6443...
INFO API v1.24.0 up
INFO Waiting up to 30m0s for bootstrapping to complete...
INFO It is now safe to remove the bootstrap resources
```

The command succeeds when the Kubernetes API server signals that it has been bootstrapped on the control plane machines.

2. After the bootstrap process is complete, remove the bootstrap machine from the load balancer.



IMPORTANT

You must remove the bootstrap machine from the load balancer at this point. You can also remove or reformat the bootstrap machine itself.

22.6.20. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The

kubeconfig file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

Example output

```
system:admin
```

22.6.21. Approving the certificate signing requests for your machines

When you add machines to a cluster, two pending certificate signing requests (CSRs) are generated for each machine that you added. You must confirm that these CSRs are approved or, if necessary, approve them yourself. The client requests must be approved first, followed by the server requests.

Prerequisites

- You added machines to your cluster.

Procedure

1. Confirm that the cluster recognizes the machines:

```
$ oc get nodes
```

Example output

```
NAME      STATUS    ROLES   AGE  VERSION
master-0  Ready     master  63m  v1.24.0
master-1  Ready     master  63m  v1.24.0
master-2  Ready     master  64m  v1.24.0
```

The output lists all of the machines that you created.

NOTE

The preceding output might not include the compute nodes, also known as worker nodes, until some CSRs are approved.

2. Review the pending CSRs and ensure that you see the client requests with the **Pending** or **Approved** status for each machine that you added to the cluster:

```
$ oc get csr
```

Example output

```
NAME        AGE    REQUESTOR                                                   CONDITION
csr-8b2br   15m    system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper   Pending
csr-8vnps   15m    system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper   Pending
...
```

In this example, two machines are joining the cluster. You might see more approved CSRs in the list.

3. If the CSRs were not approved, after all of the pending CSRs for the machines you added are in **Pending** status, approve the CSRs for your cluster machines:

NOTE

Because the CSRs rotate automatically, approve your CSRs within an hour of adding the machines to the cluster. If you do not approve them within an hour, the certificates will rotate, and more than two certificates will be present for each node. You must approve all of these certificates. After the client CSR is approved, the Kubelet creates a secondary CSR for the serving certificate, which requires manual approval. Then, subsequent serving certificate renewal requests are automatically approved by the **machine-approver** if the Kubelet requests a new certificate with identical parameters.

NOTE

For clusters running on platforms that are not machine API enabled, such as bare metal and other user-provisioned infrastructure, you must implement a method of automatically approving the kubelet serving certificate requests (CSRs). If a request is not approved, then the **oc exec**, **oc rsh**, and **oc logs** commands cannot succeed, because a serving certificate is required when the API server connects to the kubelet. Any operation that contacts the Kubelet endpoint requires this certificate approval to be in place. The method must watch for new CSRs, confirm that the CSR was submitted by the **node-bootstrapper** service account in the **system:node** or **system:admin** groups, and confirm the identity of the node.

- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

1 **<csr_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{{"\n"}}
{{end}}{{end}}' | xargs --no-run-if-empty oc adm certificate approve
```

NOTE

Some Operators might not become available until some CSRs are approved.

4. Now that your client requests are approved, you must review the server requests for each machine that you added to the cluster:

```
$ oc get csr
```

Example output

```
NAME        AGE     REQUESTOR                                                   CONDITION
csr-bfd72   5m26s   system:node:ip-10-0-50-126.us-east-2.compute.internal
Pending
csr-c57lv   5m26s   system:node:ip-10-0-95-157.us-east-2.compute.internal
Pending
...
```

5. If the remaining CSRs are not approved, and are in the **Pending** status, approve the CSRs for your cluster machines:

- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

1 **<csr_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{{"\n"}}
{{end}}{{end}}' | xargs oc adm certificate approve
```

6. After all client and server CSRs have been approved, the machines have the **Ready** status. Verify this by running the following command:

```
$ oc get nodes
```

Example output

```
NAME      STATUS    ROLES   AGE  VERSION
master-0  Ready     master  73m  v1.24.0
master-1  Ready     master  73m  v1.24.0
```

```
master-2  Ready    master  74m  v1.24.0
worker-0  Ready    worker  11m  v1.24.0
worker-1  Ready    worker  11m  v1.24.0
```

NOTE

It can take a few minutes after approval of the server CSRs for the machines to transition to the **Ready** status.

Additional information

- For more information on CSRs, see Certificate Signing Requests.

22.6.22. Initial Operator configuration

After the control plane initializes, you must immediately configure some Operators so that they all become available.

Prerequisites

- Your control plane has initialized.

Procedure

1. Watch the cluster components come online:

```
$ watch -n5 oc get clusteroperators
```

Example output

```
NAME                                       VERSION   AVAILABLE   PROGRESSING   DEGRADED
SINCE
authentication                             4.11.0    True        False         False      19m
baremetal                                  4.11.0    True        False         False      37m
cloud-credential                           4.11.0    True        False         False      40m
cluster-autoscaler                         4.11.0    True        False         False      37m
config-operator                            4.11.0    True        False         False      38m
console                                    4.11.0    True        False         False      26m
csi-snapshot-controller                    4.11.0    True        False         False      37m
dns                                        4.11.0    True        False         False      37m
etcd                                       4.11.0    True        False         False      36m
image-registry                             4.11.0    True        False         False      31m
ingress                                    4.11.0    True        False         False      30m
insights                                   4.11.0    True        False         False      31m
kube-apiserver                             4.11.0    True        False         False      26m
kube-controller-manager                    4.11.0    True        False         False      36m
kube-scheduler                             4.11.0    True        False         False      36m
kube-storage-version-migrator              4.11.0    True        False         False      37m
machine-api                                4.11.0    True        False         False      29m
machine-approver                           4.11.0    True        False         False      37m
machine-config                             4.11.0    True        False         False      36m
marketplace                                4.11.0    True        False         False      37m
monitoring                                 4.11.0    True        False         False      29m
network                                    4.11.0    True        False         False      38m
```

```
node-tuning                                4.11.0    True        False         False      37m
openshift-apiserver                        4.11.0    True        False         False      32m
openshift-controller-manager               4.11.0    True        False         False      30m
openshift-samples                          4.11.0    True        False         False      32m
operator-lifecycle-manager                 4.11.0    True        False         False      37m
operator-lifecycle-manager-catalog         4.11.0    True        False         False      37m
operator-lifecycle-manager-packageserver   4.11.0    True        False         False      32m
service-ca                                 4.11.0    True        False         False      38m
storage                                    4.11.0    True        False         False      37m
```

2. Configure the Operators that are not available.

22.6.22.1. Image registry removed during installation

On platforms that do not provide shareable object storage, the OpenShift Image Registry Operator bootstraps itself as **Removed**. This allows **openshift-installer** to complete installations on these platform types.

After installation, you must edit the Image Registry Operator configuration to switch the **managementState** from **Removed** to **Managed**.

22.6.22.2. Image registry storage configuration

The Image Registry Operator is not initially available for platforms that do not provide default storage. After installation, you must configure your registry to use storage so that the Registry Operator is made available.

Instructions are shown for configuring a persistent volume, which is required for production clusters. Where applicable, instructions are shown for configuring an empty directory as the storage location, which is available for only non-production clusters.

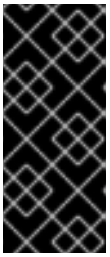
Additional instructions are provided for allowing the image registry to use block storage types by using the **Recreate** rollout strategy during upgrades.

22.6.22.2.1. Configuring registry storage for VMware vSphere

As a cluster administrator, following installation you must configure your registry to use storage.

Prerequisites

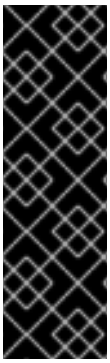
- Cluster administrator permissions.
- A cluster on VMware vSphere.
- Persistent storage provisioned for your cluster, such as Red Hat OpenShift Data Foundation.



IMPORTANT

OpenShift Container Platform supports **ReadWriteOnce** access for image registry storage when you have only one replica. **ReadWriteOnce** access also requires that the registry uses the **Recreate** rollout strategy. To deploy an image registry that supports high availability with two or more replicas, **ReadWriteMany** access is required.

- Must have "100Gi" capacity.



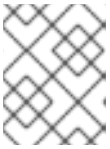
IMPORTANT

Testing shows issues with using the NFS server on RHEL as storage backend for core services. This includes the OpenShift Container Registry and Quay, Prometheus for monitoring storage, and Elasticsearch for logging storage. Therefore, using RHEL NFS to back PVs used by core services is not recommended.

Other NFS implementations on the marketplace might not have these issues. Contact the individual NFS implementation vendor for more information on any testing that was possibly completed against these OpenShift Container Platform core components.

Procedure

1. To configure your registry to use storage, change the **spec.storage.pvc** in the **configs.imageregistry/cluster** resource.



NOTE

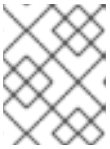
When you use shared storage, review your security settings to prevent outside access.

2. Verify that you do not have a registry pod:

```
$ oc get pod -n openshift-image-registry -l docker-registry=default
```

Example output

```
No resourses found in openshift-image-registry namespace
```



NOTE

If you do have a registry pod in your output, you do not need to continue with this procedure.

3. Check the registry configuration:

```
$ oc edit configs.imageregistry.operator.openshift.io
```

Example output

```
storage:
  pvc:
    claim: 1
```

1 Leave the **claim** field blank to allow the automatic creation of an **image-registry-storage** persistent volume claim (PVC). The PVC is generated based on the default storage class. However, be aware that the default storage class might provide ReadWriteOnce (RWO) volumes, such as a RADOS Block Device (RBD), which can cause issues when you replicate to more than one replica.

4. Check the **clusteroperator** status:

```
$ oc get clusteroperator image-registry
```

Example output

```
NAME             VERSION                             AVAILABLE   PROGRESSING   DEGRADED
SINCE   MESSAGE
image-registry   4.7                                 True        False         False     6h50m
```

22.6.22.2.2. Configuring storage for the image registry in non-production clusters

You must configure storage for the Image Registry Operator. For non-production clusters, you can set the image registry to an empty directory. If you do so, all images are lost if you restart the registry.

Procedure

- To set the image registry storage to an empty directory:

```
$ oc patch configs.imageregistry.operator.openshift.io cluster --type merge --patch '{"spec":
{"storage":{"emptyDir":{}}}}'
```

WARNING

Configure this option for only non-production clusters.

If you run this command before the Image Registry Operator initializes its components, the **oc patch** command fails with the following error:

```
Error from server (NotFound): configs.imageregistry.operator.openshift.io "cluster" not found
```

Wait a few minutes and run the command again.

22.6.22.2.3. Configuring block registry storage for VMware vSphere

To allow the image registry to use block storage types such as vSphere Virtual Machine Disk (VMDK) during upgrades as a cluster administrator, you can use the **Recreate** rollout strategy.

IMPORTANT

Block storage volumes are supported but not recommended for use with image registry on production clusters. An installation where the registry is configured on block storage is not highly available because the registry cannot have more than one replica.

Procedure

1. Enter the following command to set the image registry storage as a block storage type, patch the registry so that it uses the **Recreate** rollout strategy, and runs with only **1** replica:

```
$ oc patch config.imageregistry.operator.openshift.io/cluster --type=merge -p '{"spec":
{"rolloutStrategy":"Recreate","replicas":1}}'
```

2. Provision the PV for the block storage device, and create a PVC for that volume. The requested block volume uses the ReadWriteOnce (RWO) access mode.

   a. Create a **pvc.yaml** file with the following contents to define a VMware vSphere **PersistentVolumeClaim** object:

```
kind: PersistentVolumeClaim
apiVersion: v1
metadata:
  name: image-registry-storage 1
  namespace: openshift-image-registry 2
spec:
  accessModes:
  - ReadWriteOnce 3
  resources:
    requests:
      storage: 100Gi 4
```

   1. A unique name that represents the **PersistentVolumeClaim** object.
   2. The namespace for the **PersistentVolumeClaim** object, which is **openshift-image-registry**.
   3. The access mode of the persistent volume claim. With **ReadWriteOnce**, the volume can be mounted with read and write permissions by a single node.
   4. The size of the persistent volume claim.

   b. Enter the following command to create the **PersistentVolumeClaim** object from the file:

```
$ oc create -f pvc.yaml -n openshift-image-registry
```

3. Enter the following command to edit the registry configuration so that it references the correct PVC:

```
$ oc edit config.imageregistry.operator.openshift.io -o yaml
```

Example output

```
storage:
  pvc:
    claim: 1
```

1. By creating a custom PVC, you can leave the **claim** field blank for the default automatic creation of an **image-registry-storage** PVC.

For instructions about configuring registry storage so that it references the correct PVC, see Configuring the registry for vSphere.

22.6.23. Completing installation on user-provisioned infrastructure

After you complete the Operator configuration, you can finish installing the cluster on infrastructure that you provide.

Prerequisites

- Your control plane has initialized.
- You have completed the initial Operator configuration.

Procedure

1. Confirm that all the cluster components are online with the following command:

```
$ watch -n5 oc get clusteroperators
```

Example output

```
NAME                                       VERSION   AVAILABLE   PROGRESSING   DEGRADED
SINCE
authentication                             4.11.0    True        False         False      19m
baremetal                                  4.11.0    True        False         False      37m
cloud-credential                           4.11.0    True        False         False      40m
cluster-autoscaler                         4.11.0    True        False         False      37m
config-operator                            4.11.0    True        False         False      38m
console                                    4.11.0    True        False         False      26m
csi-snapshot-controller                    4.11.0    True        False         False      37m
dns                                        4.11.0    True        False         False      37m
etcd                                       4.11.0    True        False         False      36m
image-registry                             4.11.0    True        False         False      31m
ingress                                    4.11.0    True        False         False      30m
insights                                   4.11.0    True        False         False      31m
kube-apiserver                             4.11.0    True        False         False      26m
kube-controller-manager                    4.11.0    True        False         False      36m
kube-scheduler                             4.11.0    True        False         False      36m
kube-storage-version-migrator              4.11.0    True        False         False      37m
machine-api                                4.11.0    True        False         False      29m
machine-approver                           4.11.0    True        False         False      37m
machine-config                             4.11.0    True        False         False      36m
marketplace                                4.11.0    True        False         False      37m
monitoring                                 4.11.0    True        False         False      29m
network                                    4.11.0    True        False         False      38m
node-tuning                                4.11.0    True        False         False      37m
openshift-apiserver                        4.11.0    True        False         False      32m
openshift-controller-manager               4.11.0    True        False         False      30m
openshift-samples                          4.11.0    True        False         False      32m
operator-lifecycle-manager                 4.11.0    True        False         False      37m
operator-lifecycle-manager-catalog         4.11.0    True        False         False      37m
operator-lifecycle-manager-packageserver   4.11.0    True        False         False      32m
service-ca                                 4.11.0    True        False         False      38m
storage                                    4.11.0    True        False         False      37m
```

Alternatively, the following command notifies you when all of the clusters are available. It also retrieves and displays credentials:

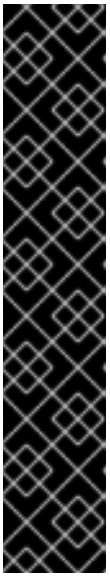
```
$ ./openshift-install --dir <installation_directory> wait-for install-complete 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

Example output

```
INFO Waiting up to 30m0s for the cluster to initialize...
```

The command succeeds when the Cluster Version Operator finishes deploying the OpenShift Container Platform cluster from Kubernetes API server.



IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

2. Confirm that the Kubernetes API server is communicating with the pods.
   a. To view a list of all pods, use the following command:

```
$ oc get pods --all-namespaces
```

Example output

```
NAMESPACE                    NAME                                        READY   STATUS
RESTARTS   AGE
openshift-apiserver-operator      openshift-apiserver-operator-85cb746d55-zqhs8   1/1
Running     1          9m
openshift-apiserver               apiserver-67b9g                          1/1     Running     0
3m
openshift-apiserver               apiserver-ljcmx                          1/1     Running     0
1m
openshift-apiserver               apiserver-z25h4                          1/1     Running     0
2m
openshift-authentication-operator authentication-operator-69d5d8bf84-vh2n8        1/1
Running     0          5m
...
```

b. View the logs for a pod that is listed in the output of the previous command by using the following command:

```
$ oc logs <pod_name> -n <namespace> 1
```

1 Specify the pod name and namespace, as shown in the output of the previous command.

If the pod logs display, the Kubernetes API server can communicate with the cluster machines.

3. For an installation with Fibre Channel Protocol (FCP), additional steps are required to enable multipathing. Do not enable multipathing during installation.
See "Enabling multipathing with kernel arguments on RHCOS" in the *Post-installation machine configuration tasks* documentation for more information.

You can add extra compute machines after the cluster installation is completed by following Adding compute machines to vSphere.

22.6.24. Backing up VMware vSphere volumes

OpenShift Container Platform provisions new volumes as independent persistent disks to freely attach and detach the volume on any node in the cluster. As a consequence, it is not possible to back up volumes that use snapshots, or to restore volumes from snapshots. See Snapshot Limitations for more information.

Procedure

To create a backup of persistent volumes:

1. Stop the application that is using the persistent volume.
2. Clone the persistent volume.
3. Restart the application.
4. Create a backup of the cloned volume.
5. Delete the cloned volume.

22.6.25. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.11, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to OpenShift Cluster Manager Hybrid Cloud Console.

After you confirm that your OpenShift Cluster Manager Hybrid Cloud Console inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, use subscription watch to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

Additional resources

- See About remote health monitoring for more information about the Telemetry service

22.6.26. Next steps

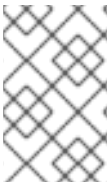
- Customize your cluster.
- If necessary, you can opt out of remote health reporting .
- Set up your registry and configure registry storage .
- Optional: View the events from the vSphere Problem Detector Operator to determine if the cluster has permission or storage configuration issues.

22.7. INSTALLING A CLUSTER ON VMC WITH USER-PROVISIONED INFRASTRUCTURE AND NETWORK CUSTOMIZATIONS

In OpenShift Container Platform version 4.11, you can install a cluster on your VMware vSphere instance using infrastructure you provision with customized network configuration options by deploying it to VMware Cloud (VMC) on AWS.

Once you configure your VMC environment for OpenShift Container Platform deployment, you use the OpenShift Container Platform installation program from the bastion management host, co-located in the VMC environment. The installation program and control plane automates the process of deploying and managing the resources needed for the OpenShift Container Platform cluster.

By customizing your network configuration, your cluster can coexist with existing IP address allocations in your environment and integrate with existing VXLAN configurations. You must set most of the network configuration parameters during installation, and you can modify only **kubeProxy** configuration parameters in a running cluster.

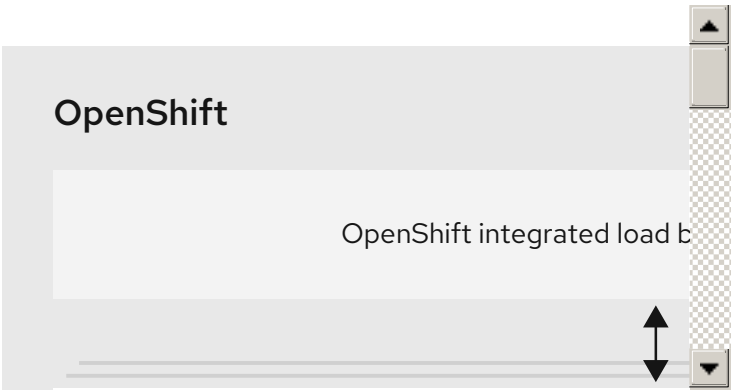


NOTE

OpenShift Container Platform supports deploying a cluster to a single VMware vCenter only. Deploying a cluster with machines/machine sets on multiple vCenters is not supported.

22.7.1. Setting up VMC for vSphere

You can install OpenShift Container Platform on VMware Cloud (VMC) on AWS hosted vSphere clusters to enable applications to be deployed and managed both on-premise and off-premise, across the hybrid cloud.



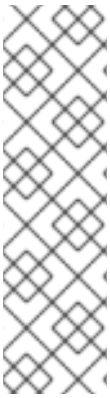
You must configure several options in your VMC environment prior to installing OpenShift Container Platform on VMware vSphere. Ensure your VMC environment has the following prerequisites:

- Create a non-exclusive, DHCP-enabled, NSX-T network segment and subnet. Other virtual machines (VMs) can be hosted on the subnet, but at least eight IP addresses must be available for the OpenShift Container Platform deployment.
- Configure the following firewall rules:
  - An ANY:ANY firewall rule between the OpenShift Container Platform compute network and the internet. This is used by nodes and applications to download container images.
  - An ANY:ANY firewall rule between the installation host and the software-defined data center (SDDC) management network on port 443. This allows you to upload the Red Hat Enterprise Linux CoreOS (RHCOS) OVA during deployment.
  - An HTTPS firewall rule between the OpenShift Container Platform compute network and vCenter. This connection allows OpenShift Container Platform to communicate with vCenter for provisioning and managing nodes, persistent volume claims (PVCs), and other resources.
- You must have the following information to deploy OpenShift Container Platform:
  - The OpenShift Container Platform cluster name, such as **vmc-prod-1**.
  - The base DNS name, such as **companyname.com**.
  - If not using the default, the pod network CIDR and services network CIDR must be identified, which are set by default to **10.128.0.0/14** and **172.30.0.0/16**, respectively. These CIDRs are used for pod-to-pod and pod-to-service communication and are not accessible externally; however, they must not overlap with existing subnets in your organization.
  - The following vCenter information:
    - vCenter hostname, username, and password
    - Datacenter name, such as **SDDC-Datacenter**
    - Cluster name, such as **Cluster-1**
    - Network name
    - Datastore name, such as **WorkloadDatastore**

NOTE

It is recommended to move your vSphere cluster to the VMC **Compute-ResourcePool** resource pool after your cluster installation is finished.

- A Linux-based host deployed to VMC as a bastion.
  - The bastion host can be Red Hat Enterprise Linux (RHEL) or any another Linux-based host; it must have internet connectivity and the ability to upload an OVA to the ESXi hosts.
  - Download and install the OpenShift CLI tools to the bastion host.
    - The **openshift-install** installation program
    - The OpenShift CLI (**oc**) tool



NOTE

You cannot use the VMware NSX Container Plugin for Kubernetes (NCP), and NSX is not used as the OpenShift SDN. The version of NSX currently available with VMC is incompatible with the version of NCP certified with OpenShift Container Platform.

However, the NSX DHCP service is used for virtual machine IP management with the full-stack automated OpenShift Container Platform deployment and with nodes provisioned, either manually or automatically, by the Machine API integration with vSphere. Additionally, NSX firewall rules are created to enable access with the OpenShift Container Platform cluster and between the bastion host and the VMC vSphere hosts.

22.7.1.1. VMC Sizer tool

VMware Cloud on AWS is built on top of AWS bare metal infrastructure; this is the same bare metal infrastructure which runs AWS native services. When a VMware cloud on AWS software-defined data center (SDDC) is deployed, you consume these physical server nodes and run the VMware ESXi hypervisor in a single tenant fashion. This means the physical infrastructure is not accessible to anyone else using VMC. It is important to consider how many physical hosts you will need to host your virtual infrastructure.

To determine this, VMware provides the VMC on AWS Sizer. With this tool, you can define the resources you intend to host on VMC:

- Types of workloads
- Total number of virtual machines
- Specification information such as:
  - Storage requirements
  - vCPUs
  - vRAM
  - Overcommit ratios

With these details, the sizer tool can generate a report, based on VMware best practices, and recommend your cluster configuration and the number of hosts you will need.

22.7.2. vSphere prerequisites

- You reviewed details about the OpenShift Container Platform installation and update processes.
- You read the documentation on selecting a cluster installation method and preparing it for users.
- You provisioned block registry storage. For more information on persistent storage, see Understanding persistent storage.
- If you use a firewall, you configured it to allow the sites that your cluster requires access to.

22.7.3. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.11, you require access to the internet to install your cluster.

You must have internet access to:

- Access OpenShift Cluster Manager Hybrid Cloud Console to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access Quay.io to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.

IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

22.7.4. VMware vSphere infrastructure requirements

You must install the OpenShift Container Platform cluster on a VMware vSphere version 7 instance that meets the requirements for the components that you use.

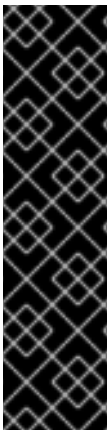
NOTE

OpenShift Container Platform version 4.11 does not support VMware vSphere version 8.0.

You can host the VMware vSphere infrastructure on-premise or on a VMware Cloud Verified provider that meets the requirements outlined in the following table:

Table 22.59. Version requirements for vSphere virtual environments

Virtual environment product	Required version
VM hardware version	15 or later
vSphere ESXi hosts	7
vCenter host	7



IMPORTANT

Installing a cluster on VMware vSphere version 7.0 Update 1 or earlier is now deprecated. These versions are still fully supported, but version 4.11 of OpenShift Container Platform requires vSphere virtual hardware version 15 or later. Hardware version 15 is now the default for vSphere virtual machines in OpenShift Container Platform. To update the hardware version for your vSphere nodes, see the "Updating hardware on nodes running in vSphere" article.

If your vSphere nodes are below hardware version 15 or your VMware vSphere version is earlier than 6.7.3, upgrading from OpenShift Container Platform 4.10 to OpenShift Container Platform 4.11 is not available.

Table 22.60. Minimum supported vSphere version for VMware components

Component	Minimum supported versions	Description
Hypervisor	vSphere 7 with HW version 15	This version is the minimum version that Red Hat Enterprise Linux CoreOS (RHCOS) supports. For more information about supported hardware on the latest version of Red Hat Enterprise Linux (RHEL) that is compatible with RHCOS, see Hardware on the Red Hat Customer Portal.
Storage with in-tree drivers	vSphere 7	This plugin creates vSphere storage by using the in-tree storage drivers for vSphere included in OpenShift Container Platform.

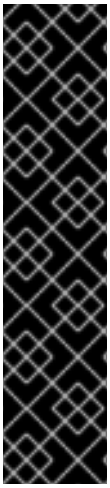
IMPORTANT

You must ensure that the time on your ESXi hosts is synchronized before you install OpenShift Container Platform. See Edit Time Configuration for a Host in the VMware documentation.

22.7.5. VMware vSphere CSI Driver Operator requirements

To install the vSphere CSI Driver Operator, the following requirements must be met:

- VMware vSphere version 7.0 Update 1 or later
- Virtual machines of hardware version 15 or later
- No third-party vSphere CSI driver already installed in the cluster



IMPORTANT

If a third-party vSphere CSI driver is present in the cluster, OpenShift Container Platform does not overwrite it. If you continue with the third-party vSphere CSI driver when upgrading to the next major version of OpenShift Container Platform, the **oc** CLI prompts you with the following message:

> VSphereCSIDriverOperatorCRUpgradeable: VMwareVSphereControllerUpgradeable: found existing unsupported csi.vsphere.vmware.com driver

The previous message informs you that Red Hat does not support the third-party vSphere CSI driver during an OpenShift Container Platform upgrade operation. You can choose to ignore this message and continue with the upgrade operation.

Additional resources

- To remove a third-party CSI driver, see Removing a third-party vSphere CSI Driver .
- To update the hardware version for your vSphere nodes, see Updating hardware on nodes running in vSphere.

22.7.6. Requirements for a cluster with user-provisioned infrastructure

For a cluster that contains user-provisioned infrastructure, you must deploy all of the required machines.

This section describes the requirements for deploying OpenShift Container Platform on user-provisioned infrastructure.

22.7.6.1. Required machines for cluster installation

The smallest OpenShift Container Platform clusters require the following hosts:

Table 22.61. Minimum required hosts

Hosts	Description
One temporary bootstrap machine	The cluster requires the bootstrap machine to deploy the OpenShift Container Platform cluster on the three control plane machines. You can remove the bootstrap machine after you install the cluster.
Three control plane machines	The control plane machines run the Kubernetes and OpenShift Container Platform services that form the control plane.
At least two compute machines, which are also known as worker machines.	The workloads requested by OpenShift Container Platform users run on the compute machines.

IMPORTANT

To maintain high availability of your cluster, use separate physical hosts for these cluster machines.

The bootstrap and control plane machines must use Red Hat Enterprise Linux CoreOS (RHCOS) as the operating system. However, the compute machines can choose between Red Hat Enterprise Linux CoreOS (RHCOS), Red Hat Enterprise Linux (RHEL) 8.6 and later.

Note that RHCOS is based on Red Hat Enterprise Linux (RHEL) 8 and inherits all of its hardware certifications and requirements. See Red Hat Enterprise Linux technology capabilities and limits .

22.7.6.2. Minimum resource requirements for cluster installation

Each cluster machine must meet the following minimum requirements:

Table 22.62. Minimum resource requirements

Machine	Operating System	vCPU [1]	Virtual RAM	Storage	IOPS [2]
Bootstrap	RHCOS	4	16 GB	100 GB	300
Control plane	RHCOS	4	16 GB	100 GB	300
Compute	RHCOS, RHEL 8.6 and later [3]	2	8 GB	100 GB	300

1. One vCPU is equivalent to one physical core when simultaneous multithreading (SMT), or hyperthreading, is not enabled. When enabled, use the following formula to calculate the corresponding ratio: (threads per core × cores) × sockets = vCPUs.

2. OpenShift Container Platform and Kubernetes are sensitive to disk performance, and faster storage is recommended, particularly for etcd on the control plane nodes which require a 10 ms p99 fsync duration. Note that on many cloud platforms, storage size and IOPS scale together, so you might need to over-allocate storage volume to obtain sufficient performance.

3. As with all user-provisioned installations, if you choose to use RHEL compute machines in your cluster, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks. Use of RHEL 7 compute machines is deprecated and has been removed in OpenShift Container Platform 4.10 and later.

If an instance type for your platform meets the minimum requirements for cluster machines, it is supported to use in OpenShift Container Platform.

22.7.6.3. Certificate signing requests management

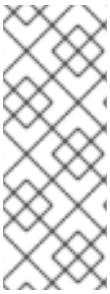
Because your cluster has limited access to automatic machine management when you use infrastructure that you provision, you must provide a mechanism for approving cluster certificate signing requests (CSRs) after installation. The **kube-controller-manager** only approves the kubelet client CSRs. The **machine-approver** cannot guarantee the validity of a serving certificate that is requested by using kubelet credentials because it cannot confirm that the correct machine issued the request. You must determine and implement a method of verifying the validity of the kubelet serving certificate requests and approving them.

22.7.6.4. Networking requirements for user-provisioned infrastructure

All the Red Hat Enterprise Linux CoreOS (RHCOS) machines require networking to be configured in **initramfs** during boot to fetch their Ignition config files.

During the initial boot, the machines require an IP address configuration that is set either through a DHCP server or statically by providing the required boot options. After a network connection is established, the machines download their Ignition config files from an HTTP or HTTPS server. The Ignition config files are then used to set the exact state of each machine. The Machine Config Operator completes more changes to the machines, such as the application of new certificates or keys, after installation.

It is recommended to use a DHCP server for long-term management of the cluster machines. Ensure that the DHCP server is configured to provide persistent IP addresses, DNS server information, and hostnames to the cluster machines.



NOTE

If a DHCP service is not available for your user-provisioned infrastructure, you can instead provide the IP networking configuration and the address of the DNS server to the nodes at RHCOS install time. These can be passed as boot arguments if you are installing from an ISO image. See the *Installing RHCOS and starting the OpenShift Container Platform bootstrap process* section for more information about static IP provisioning and advanced networking options.

The Kubernetes API server must be able to resolve the node names of the cluster machines. If the API servers and worker nodes are in different zones, you can configure a default DNS search zone to allow the API server to resolve the node names. Another supported approach is to always refer to hosts by their fully-qualified domain names in both the node objects and all DNS requests.

22.7.6.4.1. Setting the cluster node hostnames through DHCP

On Red Hat Enterprise Linux CoreOS (RHCOS) machines, the hostname is set through NetworkManager. By default, the machines obtain their hostname through DHCP. If the hostname is not provided by DHCP, set statically through kernel arguments, or another method, it is obtained through a reverse DNS lookup. Reverse DNS lookup occurs after the network has been initialized on a node and can take time to resolve. Other system services can start prior to this and detect the hostname as **localhost** or similar. You can avoid this by using DHCP to provide the hostname for each cluster node.

Additionally, setting the hostnames through DHCP can bypass any manual DNS record name configuration errors in environments that have a DNS split-horizon implementation.

22.7.6.4.2. Network connectivity requirements

You must configure the network connectivity between machines to allow OpenShift Container Platform cluster components to communicate. Each machine must be able to resolve the hostnames of all other machines in the cluster.

This section provides details about the ports that are required.

IMPORTANT

In connected OpenShift Container Platform environments, all nodes are required to have internet access to pull images for platform containers and provide telemetry data to Red Hat.

Table 22.63. Ports used for all-machine to all-machine communications

Protocol	Port	Description
ICMP	N/A	Network reachability tests
TCP	**1936**	Metrics
	9000-**9999**	Host level services, including the node exporter on ports **9100**-**9101** and the Cluster Version Operator on port**9099**.
	10250-**10259**	The default ports that Kubernetes reserves
	10256	openshift-sdn
UDP	**4789**	VXLAN
	6081	Geneve
	9000-**9999**	Host level services, including the node exporter on ports **9100**-**9101**.
	500	IPsec IKE packets
	4500	IPsec NAT-T packets
TCP/UDP	**30000**-**32767**	Kubernetes node port
ESP	N/A	IPsec Encapsulating Security Payload (ESP)

Table 22.64. Ports used for all-machine to control plane communications

Protocol	Port	Description
TCP	**6443**	Kubernetes API

Table 22.65. Ports used for control plane machine to control plane machine communications

Protocol	Port	Description
TCP	**2379**-**2380**	etcd server and peer ports

Ethernet adaptor hardware address requirements

When provisioning VMs for the cluster, the ethernet interfaces configured for each VM must use a MAC address from the VMware Organizationally Unique Identifier (OUI) allocation ranges:

- **00:05:69:00:00:00** to **00:05:69:FF:FF:FF**

- **00:0c:29:00:00:00** to **00:0c:29:FF:FF:FF**
- **00:1c:14:00:00:00** to **00:1c:14:FF:FF:FF**
- **00:50:56:00:00:00** to **00:50:56:3F:FF:FF**

If a MAC address outside the VMware OUI is used, the cluster installation will not succeed.

NTP configuration for user-provisioned infrastructure
OpenShift Container Platform clusters are configured to use a public Network Time Protocol (NTP) server by default. If you want to use a local enterprise NTP server, or if your cluster is being deployed in a disconnected network, you can configure the cluster to use a specific time server. For more information, see the documentation for *Configuring chrony time service* .

If a DHCP server provides NTP server information, the chrony time service on the Red Hat Enterprise Linux CoreOS (RHCOS) machines read the information and can sync the clock with the NTP servers.

22.7.6.5. User-provisioned DNS requirements

In OpenShift Container Platform deployments, DNS name resolution is required for the following components:

- The Kubernetes API
- The OpenShift Container Platform application wildcard
- The bootstrap, control plane, and compute machines

Reverse DNS resolution is also required for the Kubernetes API, the bootstrap machine, the control plane machines, and the compute machines.

DNS A/AAAA or CNAME records are used for name resolution and PTR records are used for reverse name resolution. The reverse records are important because Red Hat Enterprise Linux CoreOS (RHCOS) uses the reverse records to set the hostnames for all the nodes, unless the hostnames are provided by DHCP. Additionally, the reverse records are used to generate the certificate signing requests (CSR) that OpenShift Container Platform needs to operate.

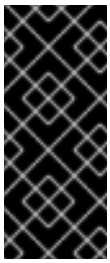
NOTE

It is recommended to use a DHCP server to provide the hostnames to each cluster node. See the *DHCP recommendations for user-provisioned infrastructure* section for more information.

The following DNS records are required for a user-provisioned OpenShift Container Platform cluster and they must be in place before installation. In each record, **<cluster_name>** is the cluster name and **<base_domain>** is the base domain that you specify in the **install-config.yaml** file. A complete DNS record takes the form: **<component>.<cluster_name>.<base_domain>.**.

Table 22.66. Required DNS records

Component	Record	Description

Component	Record	Description
Kubernetes API	**api.<cluster_name>.<base_domain>.**	A DNS A/AAAA or CNAME record, and a DNS PTR record, to identify the API load balancer. These records must be resolvable by both clients external to the cluster and from all the nodes within the cluster.
	api-int.<cluster_name>.<base_domain>.	A DNS A/AAAA or CNAME record, and a DNS PTR record, to internally identify the API load balancer. These records must be resolvable from all the nodes within the cluster.  **IMPORTANT** The API server must be able to resolve the worker nodes by the hostnames that are recorded in Kubernetes. If the API server cannot resolve the node names, then proxied API calls can fail, and you cannot retrieve logs from pods.
Routes	***.apps.<cluster_name>.<base_domain>.**	A wildcard DNS A/AAAA or CNAME record that refers to the application ingress load balancer. The application ingress load balancer targets the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default. These records must be resolvable by both clients external to the cluster and from all the nodes within the cluster. For example, **console-openshift-console.apps.<cluster_name>.<base_domain>** is used as a wildcard route to the OpenShift Container Platform console.
Bootstrap machine	**bootstrap.<cluster_name>.<base_domain>.**	A DNS A/AAAA or CNAME record, and a DNS PTR record, to identify the bootstrap machine. These records must be resolvable by the nodes within the cluster.
Control plane machines	**<master><n>.<cluster_name>.<base_domain>.**	DNS A/AAAA or CNAME records and DNS PTR records to identify each machine for the control plane nodes. These records must be resolvable by the nodes within the cluster.
Compute machines	**<worker><n>.<cluster_name>.<base_domain>.**	DNS A/AAAA or CNAME records and DNS PTR records to identify each machine for the worker nodes. These records must be resolvable by the nodes within the cluster.

NOTE

In OpenShift Container Platform 4.4 and later, you do not need to specify etcd host and SRV records in your DNS configuration.

TIP

You can use the **dig** command to verify name and reverse name resolution. See the section on *Validating DNS resolution for user-provisioned infrastructure* for detailed validation steps.

22.7.6.5.1. Example DNS configuration for user-provisioned clusters

This section provides A and PTR record configuration samples that meet the DNS requirements for deploying OpenShift Container Platform on user-provisioned infrastructure. The samples are not meant to provide advice for choosing one DNS solution over another.

In the examples, the cluster name is **ocp4** and the base domain is **example.com**.

Example DNS A record configuration for a user-provisioned cluster

The following example is a BIND zone file that shows sample A records for name resolution in a user-provisioned cluster.

Example 22.16. Sample DNS zone database

```
$TTL 1W
@ IN SOA ns1.example.com. root (
  2019070700 ; serial
  3H  ; refresh (3 hours)
  30M  ; retry (30 minutes)
  2W  ; expiry (2 weeks)
  1W )  ; minimum (1 week)
 IN NS ns1.example.com.
 IN MX 10 smtp.example.com.
;
;
ns1.example.com.  IN A 192.168.1.5
smtp.example.com.  IN A 192.168.1.5
;
helper.example.com.  IN A 192.168.1.5
helper.ocp4.example.com. IN A 192.168.1.5
;
api.ocp4.example.com.  IN A 192.168.1.5 1
api-int.ocp4.example.com. IN A 192.168.1.5 2
;
*.apps.ocp4.example.com. IN A 192.168.1.5 3
;
bootstrap.ocp4.example.com. IN A 192.168.1.96 4
;
master0.ocp4.example.com. IN A 192.168.1.97 5
master1.ocp4.example.com. IN A 192.168.1.98 6
master2.ocp4.example.com. IN A 192.168.1.99 7
;
worker0.ocp4.example.com. IN A 192.168.1.11 8
```

```
worker1.ocp4.example.com. IN A 192.168.1.7 9
;
;EOF
```

1 Provides name resolution for the Kubernetes API. The record refers to the IP address of the API load balancer.

2 Provides name resolution for the Kubernetes API. The record refers to the IP address of the API load balancer and is used for internal cluster communications.

3 Provides name resolution for the wildcard routes. The record refers to the IP address of the application ingress load balancer. The application ingress load balancer targets the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.

NOTE

In the example, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

4 Provides name resolution for the bootstrap machine.

5 6 7 Provides name resolution for the control plane machines.

8 9 Provides name resolution for the compute machines.

Example DNS PTR record configuration for a user-provisioned cluster

The following example BIND zone file shows sample PTR records for reverse name resolution in a user-provisioned cluster.

Example 22.17. Sample DNS zone database for reverse records

```
$TTL 1W
@ IN SOA ns1.example.com. root (
  2019070700 ; serial
  3H  ; refresh (3 hours)
  30M  ; retry (30 minutes)
  2W  ; expiry (2 weeks)
  1W )  ; minimum (1 week)
 IN NS ns1.example.com.
;
5.1.168.192.in-addr.arpa. IN PTR api.ocp4.example.com. 1
5.1.168.192.in-addr.arpa. IN PTR api-int.ocp4.example.com. 2
;
96.1.168.192.in-addr.arpa. IN PTR bootstrap.ocp4.example.com. 3
;
97.1.168.192.in-addr.arpa. IN PTR master0.ocp4.example.com. 4
98.1.168.192.in-addr.arpa. IN PTR master1.ocp4.example.com. 5
99.1.168.192.in-addr.arpa. IN PTR master2.ocp4.example.com. 6
```

```
;
11.1.168.192.in-addr.arpa. IN PTR worker0.ocp4.example.com. 7
7.1.168.192.in-addr.arpa. IN PTR worker1.ocp4.example.com. 8
;
;EOF
```

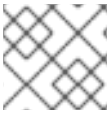
1 Provides reverse DNS resolution for the Kubernetes API. The PTR record refers to the record name of the API load balancer.

2 Provides reverse DNS resolution for the Kubernetes API. The PTR record refers to the record name of the API load balancer and is used for internal cluster communications.

3 Provides reverse DNS resolution for the bootstrap machine.

4 5 6 Provides reverse DNS resolution for the control plane machines.

7 8 Provides reverse DNS resolution for the compute machines.

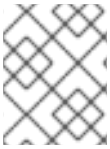


NOTE

A PTR record is not required for the OpenShift Container Platform application wildcard.

22.7.6.6. Load balancing requirements for user-provisioned infrastructure

Before you install OpenShift Container Platform, you must provision the API and application ingress load balancing infrastructure. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.



NOTE

If you want to deploy the API and application Ingress load balancers with a Red Hat Enterprise Linux (RHEL) instance, you must purchase the RHEL subscription separately.

The load balancing infrastructure must meet the following requirements:

1. **API load balancer**: Provides a common endpoint for users, both human and machine, to interact with and configure the platform. Configure the following conditions:

   - Layer 4 load balancing only. This can be referred to as Raw TCP, SSL Passthrough, or SSL Bridge mode. If you use SSL Bridge mode, you must enable Server Name Indication (SNI) for the API routes.

   - A stateless load balancing algorithm. The options vary based on the load balancer implementation.

IMPORTANT

Do not configure session persistence for an API load balancer. Configuring session persistence for a Kubernetes API server might cause performance issues from excess application traffic for your OpenShift Container Platform cluster and the Kubernetes API that runs inside the cluster.

Configure the following ports on both the front and back of the load balancers:

Table 22.67. API load balancer

Port	Back-end machines (pool members)	Internal	External	Description
6443	Bootstrap and control plane. You remove the bootstrap machine from the load balancer after the bootstrap machine initializes the cluster control plane. You must configure the **/readyz** endpoint for the API server health check probe.	X	X	Kubernetes API server
22623	Bootstrap and control plane. You remove the bootstrap machine from the load balancer after the bootstrap machine initializes the cluster control plane.	X		Machine config server

NOTE

The load balancer must be configured to take a maximum of 30 seconds from the time the API server turns off the **/readyz** endpoint to the removal of the API server instance from the pool. Within the time frame after **/readyz** returns an error or becomes healthy, the endpoint must have been removed or added. Probing every 5 or 10 seconds, with two successful requests to become healthy and three to become unhealthy, are well-tested values.

2. **Application Ingress load balancer**: Provides an ingress point for application traffic flowing in from outside the cluster. A working configuration for the Ingress router is required for an OpenShift Container Platform cluster.
Configure the following conditions:

   - Layer 4 load balancing only. This can be referred to as Raw TCP, SSL Passthrough, or SSL Bridge mode. If you use SSL Bridge mode, you must enable Server Name Indication (SNI) for the ingress routes.
   - A connection-based or session-based persistence is recommended, based on the options available and types of applications that will be hosted on the platform.

TIP

If the true IP address of the client can be seen by the application Ingress load balancer, enabling source IP-based session persistence can improve performance for applications that use end-to-end TLS encryption.

Configure the following ports on both the front and back of the load balancers:

Table 22.68. Application Ingress load balancer

Port	Back-end machines (pool members)	Internal	External	Description
443	The machines that run the Ingress Controller pods, compute, or worker, by default.	X	X	HTTPS traffic
80	The machines that run the Ingress Controller pods, compute, or worker, by default.	X	X	HTTP traffic

NOTE

If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application Ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes.

22.7.6.6.1. Example load balancer configuration for user-provisioned clusters

This section provides an example API and application ingress load balancer configuration that meets the load balancing requirements for user-provisioned clusters. The sample is an **/etc/haproxy/haproxy.cfg** configuration for an HAProxy load balancer. The example is not meant to provide advice for choosing one load balancing solution over another.

In the example, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

NOTE

If you are using HAProxy as a load balancer and SELinux is set to **enforcing**, you must ensure that the HAProxy service can bind to the configured TCP port by running **setsebool -P haproxy_connect_any=1**.

Example 22.18. Sample API and application Ingress load balancer configuration

```
global
  log         127.0.0.1 local2
  pidfile     /var/run/haproxy.pid
  maxconn     4000
  daemon
defaults
  mode                    http
  log                     global
  option                  dontlognull
  option http-server-close
  option                  redispatch
  retries                 3
  timeout http-request    10s
  timeout queue           1m
  timeout connect         10s
  timeout client          1m
```

```
  timeout server          1m
  timeout http-keep-alive 10s
  timeout check           10s
  maxconn                 3000
listen api-server-6443 (1)
  bind *:6443
  mode tcp
  server bootstrap bootstrap.ocp4.example.com:6443 check inter 1s backup (2)
  server master0 master0.ocp4.example.com:6443 check inter 1s
  server master1 master1.ocp4.example.com:6443 check inter 1s
  server master2 master2.ocp4.example.com:6443 check inter 1s
listen machine-config-server-22623 (3)
  bind *:22623
  mode tcp
  option  httpchk GET /readyz HTTP/1.0
  option  log-health-checks
  balance roundrobin
  server bootstrap bootstrap.ocp4.example.com:6443 verify none check check-ssl inter 10s fall 2
rise 3 backup (4)
  server master0 master0.ocp4.example.com:6443 weight 1 verify none check check-ssl inter 10s
fall 2 rise 3
  server master1 master1.ocp4.example.com:6443 weight 1 verify none check check-ssl inter 10s
fall 2 rise 3
  server master2 master2.ocp4.example.com:6443 weight 1 verify none check check-ssl inter 10s
fall 2 rise 3
listen ingress-router-443 (5)
  bind *:443
  mode tcp
  balance source
  server worker0 worker0.ocp4.example.com:443 check inter 1s
  server worker1 worker1.ocp4.example.com:443 check inter 1s
listen ingress-router-80 (6)
  bind *:80
  mode tcp
  balance source
  server worker0 worker0.ocp4.example.com:80 check inter 1s
  server worker1 worker1.ocp4.example.com:80 check inter 1s
```

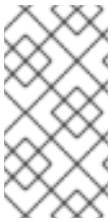
(1) Port **6443** handles the Kubernetes API traffic and points to the control plane machines.

(2) (4) The bootstrap entries must be in place before the OpenShift Container Platform cluster installation and they must be removed after the bootstrap process is complete.

(3) Port **22623** handles the machine config server traffic and points to the control plane machines.

(5) Port **443** handles the HTTPS traffic and points to the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.

(6) Port **80** handles the HTTP traffic and points to the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.



NOTE

If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application Ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes.

TIP

If you are using HAProxy as a load balancer, you can check that the **haproxy** process is listening on ports **6443**, **22623**, **443**, and **80** by running **netstat -nltupe** on the HAProxy node.

22.7.7. Preparing the user-provisioned infrastructure

Before you install OpenShift Container Platform on user-provisioned infrastructure, you must prepare the underlying infrastructure.

This section provides details about the high-level steps required to set up your cluster infrastructure in preparation for an OpenShift Container Platform installation. This includes configuring IP networking and network connectivity for your cluster nodes, enabling the required ports through your firewall, and setting up the required DNS and load balancing infrastructure.

After preparation, your cluster infrastructure must meet the requirements outlined in the *Requirements for a cluster with user-provisioned infrastructure* section.

Prerequisites

- You have reviewed the OpenShift Container Platform 4.x Tested Integrations page.
- You have reviewed the infrastructure requirements detailed in the *Requirements for a cluster with user-provisioned infrastructure* section.

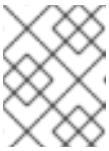
Procedure

1. If you are using DHCP to provide the IP networking configuration to your cluster nodes, configure your DHCP service.
   a. Add persistent IP addresses for the nodes to your DHCP server configuration. In your configuration, match the MAC address of the relevant network interface to the intended IP address for each node.
   b. When you use DHCP to configure IP addressing for the cluster machines, the machines also obtain the DNS server information through DHCP. Define the persistent DNS server address that is used by the cluster nodes through your DHCP server configuration.

NOTE

If you are not using a DHCP service, you must provide the IP networking configuration and the address of the DNS server to the nodes at RHCOS install time. These can be passed as boot arguments if you are installing from an ISO image. See the *Installing RHCOS and starting the OpenShift Container Platform bootstrap process* section for more information about static IP provisioning and advanced networking options.

c. Define the hostnames of your cluster nodes in your DHCP server configuration. See the *Setting the cluster node hostnames through DHCP* section for details about hostname considerations.

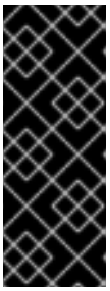


NOTE

If you are not using a DHCP service, the cluster nodes obtain their hostname through a reverse DNS lookup.

2. Ensure that your network infrastructure provides the required network connectivity between the cluster components. See the *Networking requirements for user-provisioned infrastructure* section for details about the requirements.

3. Configure your firewall to enable the ports required for the OpenShift Container Platform cluster components to communicate. See *Networking requirements for user-provisioned infrastructure* section for details about the ports that are required.



IMPORTANT

By default, port **1936** is accessible for an OpenShift Container Platform cluster, because each control plane node needs access to this port.

Avoid using the Ingress load balancer to expose this port, because doing so might result in the exposure of sensitive information, such as statistics and metrics, related to Ingress Controllers.

4. Setup the required DNS infrastructure for your cluster.

   a. Configure DNS name resolution for the Kubernetes API, the application wildcard, the bootstrap machine, the control plane machines, and the compute machines.

   b. Configure reverse DNS resolution for the Kubernetes API, the bootstrap machine, the control plane machines, and the compute machines.
   See the *User-provisioned DNS requirements* section for more information about the OpenShift Container Platform DNS requirements.

5. Validate your DNS configuration.

   a. From your installation node, run DNS lookups against the record names of the Kubernetes API, the wildcard routes, and the cluster nodes. Validate that the IP addresses in the responses correspond to the correct components.

   b. From your installation node, run reverse DNS lookups against the IP addresses of the load balancer and the cluster nodes. Validate that the record names in the responses correspond to the correct components.
   See the *Validating DNS resolution for user-provisioned infrastructure* section for detailed DNS validation steps.

6. Provision the required API and application ingress load balancing infrastructure. See the *Load balancing requirements for user-provisioned infrastructure* section for more information about the requirements.

NOTE

Some load balancing solutions require the DNS name resolution for the cluster nodes to be in place before the load balancing is initialized.

22.7.8. Validating DNS resolution for user-provisioned infrastructure

You can validate your DNS configuration before installing OpenShift Container Platform on user-provisioned infrastructure.

IMPORTANT

The validation steps detailed in this section must succeed before you install your cluster.

Prerequisites

- You have configured the required DNS records for your user-provisioned infrastructure.

Procedure

1. From your installation node, run DNS lookups against the record names of the Kubernetes API, the wildcard routes, and the cluster nodes. Validate that the IP addresses contained in the responses correspond to the correct components.

   a. Perform a lookup against the Kubernetes API record name. Check that the result points to the IP address of the API load balancer:

   ```
   $ dig +noall +answer @<nameserver_ip> api.<cluster_name>.<base_domain>
   ```
   (1)

   (1) Replace **<nameserver_ip>** with the IP address of the nameserver, **<cluster_name>** with your cluster name, and **<base_domain>** with your base domain name.

   Example output

   ```
   api.ocp4.example.com.  604800 IN A 192.168.1.5
   ```

   b. Perform a lookup against the Kubernetes internal API record name. Check that the result points to the IP address of the API load balancer:

   ```
   $ dig +noall +answer @<nameserver_ip> api-int.<cluster_name>.<base_domain>
   ```

   Example output

   ```
   api-int.ocp4.example.com.  604800 IN A 192.168.1.5
   ```

   c. Test an example ***.apps.<cluster_name>.<base_domain>** DNS wildcard lookup. All of the application wildcard lookups must resolve to the IP address of the application ingress load balancer:

   ```
   $ dig +noall +answer @<nameserver_ip> random.apps.<cluster_name>.<base_domain>
   ```

   Example output

```
random.apps.ocp4.example.com.  604800 IN A 192.168.1.5
```

NOTE

In the example outputs, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

You can replace **random** with another wildcard value. For example, you can query the route to the OpenShift Container Platform console:

```
$ dig +noall +answer @<nameserver_ip> console-openshift-console.apps.
<cluster_name>.<base_domain>
```

Example output

```
console-openshift-console.apps.ocp4.example.com. 604800 IN A 192.168.1.5
```

d. Run a lookup against the bootstrap DNS record name. Check that the result points to the IP address of the bootstrap node:

```
$ dig +noall +answer @<nameserver_ip> bootstrap.<cluster_name>.<base_domain>
```

Example output

```
bootstrap.ocp4.example.com.  604800 IN A 192.168.1.96
```

e. Use this method to perform lookups against the DNS record names for the control plane and compute nodes. Check that the results correspond to the IP addresses of each node.

2. From your installation node, run reverse DNS lookups against the IP addresses of the load balancer and the cluster nodes. Validate that the record names contained in the responses correspond to the correct components.

a. Perform a reverse lookup against the IP address of the API load balancer. Check that the response includes the record names for the Kubernetes API and the Kubernetes internal API:

```
$ dig +noall +answer @<nameserver_ip> -x 192.168.1.5
```

Example output

```
5.1.168.192.in-addr.arpa. 604800 IN PTR api-int.ocp4.example.com. 1
5.1.168.192.in-addr.arpa. 604800 IN PTR api.ocp4.example.com. 2
```

1 Provides the record name for the Kubernetes internal API.

2 Provides the record name for the Kubernetes API.

NOTE

A PTR record is not required for the OpenShift Container Platform application wildcard. No validation step is needed for reverse DNS resolution against the IP address of the application ingress load balancer.

b. Perform a reverse lookup against the IP address of the bootstrap node. Check that the result points to the DNS record name of the bootstrap node:

```
$ dig +noall +answer @<nameserver_ip> -x 192.168.1.96
```

Example output

```
96.1.168.192.in-addr.arpa. 604800 IN PTR bootstrap.ocp4.example.com.
```

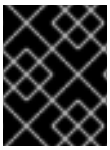
c. Use this method to perform reverse lookups against the IP addresses for the control plane and compute nodes. Check that the results correspond to the DNS record names of each node.

22.7.9. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the **~/.ssh/authorized_keys** list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The **./openshift-install gather** command also requires the SSH public key to be in place on the cluster nodes.



IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.

NOTE

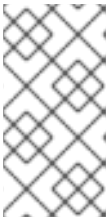
You must use a local key, not one that you configured with platform-specific approaches such as AWS key pairs.

Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N '' -f <path>/<file_name>
```
(1)

1 Specify the path and file name, such as ~/**.ssh/id_ed25519**, of the new SSH key. If you have an existing key pair, ensure your public key is in the your ~/**.ssh** directory.



NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS validated or Modules In Process cryptographic libraries on the **x86_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

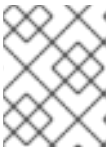
2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the ~/**.ssh/id_ed25519.pub** public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the **./openshift-install gather** command.



NOTE

On some distributions, default SSH private key identities such as ~/**.ssh/id_rsa** and ~/**.ssh/id_dsa** are managed automatically.

a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

Example output

```
Agent pid 31874
```

NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

1 Specify the path and file name for your SSH private key, such as ~/**.ssh/id_ed25519**

Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

22.7.10. Obtaining the installation program

Before you install OpenShift Container Platform, download the installation file on a local computer.

Prerequisites

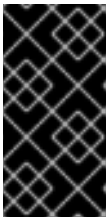
- You have a computer that runs Linux or macOS, with 500 MB of local disk space.

Procedure

1. Access the Infrastructure Provider page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program that corresponds with your host operating system and architecture, and place the file in the directory where you will store the installation configuration files.

IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.



IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation pull secret from the Red Hat OpenShift Cluster Manager . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

22.7.11. Manually creating the installation configuration file

For user-provisioned installations of OpenShift Container Platform, you manually generate your installation configuration file.

IMPORTANT

The Cluster Cloud Controller Manager Operator performs a connectivity check on a provided hostname or IP address. Ensure that you specify a hostname or an IP address to a reachable vCenter server. If you provide metadata to a non-existent vCenter server, installation of the cluster fails at the bootstrap stage.

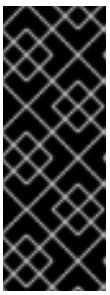
Prerequisites

- You have an SSH public key on your local machine to provide to the installation program. The key will be used for SSH authentication onto your cluster nodes for debugging and disaster recovery.
- You have obtained the OpenShift Container Platform installation program and the pull secret for your cluster.
- Obtain the **imageContentSources** section from the output of the command to mirror the repository.
- Obtain the contents of the certificate for your mirror registry.

Procedure

1. Create an installation directory to store your required installation assets in:

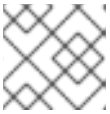
```
$ mkdir <installation_directory>
```



IMPORTANT

You must create a directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

2. Customize the sample **install-config.yaml** file template that is provided and save it in the **<installation_directory>**.



NOTE

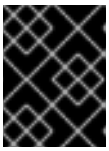
You must name this configuration file **install-config.yaml**.

- Unless you use a registry that RHCOS trusts by default, such as **docker.io**, you must provide the contents of the certificate for your mirror repository in the **additionalTrustBundle** section. In most cases, you must provide the certificate for your mirror.
- You must include the **imageContentSources** section from the output of the command to mirror the repository.

NOTE

For some platform types, you can alternatively run **./openshift-install create install-config --dir <installation_directory>** to generate an **install-config.yaml** file. You can provide details about your cluster configuration at the prompts.

3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.



IMPORTANT

The **install-config.yaml** file is consumed during the next step of the installation process. You must back it up now.

22.7.11.1. Sample install-config.yaml file for VMware vSphere

You can customize the **install-config.yaml** file to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.

```
apiVersion: v1
baseDomain: example.com (1)
compute: (2)
  name: worker
  replicas: 0 (3)
controlPlane: (4)
  name: master
  replicas: 3 (5)
metadata:
  name: test (6)
platform:
  vsphere:
    vcenter: your.vcenter.server (7)
    username: username (8)
    password: password (9)
    datacenter: datacenter (10)
    defaultDatastore: datastore (11)
    folder: "/<datacenter_name>/vm/<folder_name>/<subfolder_name>" (12)
    resourcePool: "/<datacenter_name>/host/<cluster_name>/Resources/<resource_pool_name>" (13)
    diskType: thin (14)
fips: false (15)
pullSecret: '{"auths": ...}' (16)
sshKey: 'ssh-ed25519 AAAA...' (17)
```

(1) The base domain of the cluster. All DNS records must be sub-domains of this base and include the cluster name.

(2) (4) The **controlPlane** section is a single mapping, but the compute section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, (**-**), and the first line of the **controlPlane** section must not. Although both sections currently define a single machine pool, it is possible that future versions of OpenShift Container Platform will support defining multiple compute pools during installation. Only one control plane pool is used.

3 You must set the value of the **replicas** parameter to **0**. This parameter controls the number of workers that the cluster creates and manages for you, which are functions that the cluster does not

5 The number of control plane machines that you add to the cluster. Because the cluster uses this values as the number of etcd endpoints in the cluster, the value must match the number of control plane machines that you deploy.

6 The cluster name that you specified in your DNS records.

7 The fully-qualified hostname or IP address of the vCenter server.

IMPORTANT

The Cluster Cloud Controller Manager Operator performs a connectivity check on a provided hostname or IP address. Ensure that you specify a hostname or an IP address to a reachable vCenter server. If you provide metadata to a non-existent vCenter server, installation of the cluster fails at the bootstrap stage.

8 The name of the user for accessing the server.

9 The password associated with the vSphere user.

10 The vSphere datacenter.

11 The default vSphere datastore to use.

12 Optional parameter: For installer-provisioned infrastructure, the absolute path of an existing folder where the installation program creates the virtual machines, for example, **/<datacenter_name>/vm/<folder_name>/<subfolder_name>**. If you do not provide this value, the installation program creates a top-level folder in the datacenter virtual machine folder that is named with the infrastructure ID. If you are providing the infrastructure for the cluster and you do not want to use the default **StorageClass** object, named **thin**, you can omit the **folder** parameter from the **install-config.yaml** file.

13 Optional parameter: For installer-provisioned infrastructure, the absolute path of an existing folder where the installation program creates the virtual machines, for example, **/<datacenter_name>/vm/<folder_name>/<subfolder_name>**. If you do not provide this value, the installation program creates a top-level folder in the datacenter virtual machine folder that is named with the infrastructure ID. If you are providing the infrastructure for the cluster, omit this parameter.

14 The vSphere disk provisioning method.

15 Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.

IMPORTANT

To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.

16 The pull secret that you obtained from OpenShift Cluster Manager Hybrid Cloud Console . This pull secret allows you to authenticate with the services that are provided by the included authorities,

17 The public portion of the default SSH key for the **core** user in Red Hat Enterprise Linux CoreOS (RHCOS).

22.7.11.2. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.

NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
```

1 A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.

2 A proxy URL to use for creating HTTPS connections outside the cluster.

3 A comma-separated list of destination domain names, IP addresses, or other network

4 If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace that contains one or more additional CA certificates

NOTE

The installation program does not support the proxy **readinessEndpoints** field.

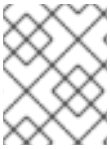
NOTE

If the installer times out, restart and then complete the deployment by using the **wait-for** command of the installer. For example:

```
$ ./openshift-install wait-for install-complete --log-level debug
```

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.

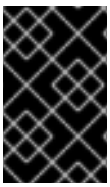


NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

22.7.12. Specifying advanced network configuration

You can use advanced network configuration for your cluster network provider to integrate your cluster into your existing network environment. You can specify advanced network configuration only before you install the cluster.



IMPORTANT

Customizing your network configuration by modifying the OpenShift Container Platform manifest files created by the installation program is not supported. Applying a manifest file that you create, as in the following procedure, is supported.

Prerequisites

- You have created the **install-config.yaml** file and completed any modifications to it.

Procedure

1. Change to the directory that contains the installation program and create the manifests:

```
$ ./openshift-install create manifests --dir <installation_directory> 1
```

1 **<installation_directory>** specifies the name of the directory that contains the **install-config.yaml** file for your cluster.

2. Create a stub manifest file for the advanced network configuration that is named **cluster-network-03-config.yml** in the **<installation_directory>/manifests/** directory:

```
apiVersion: operator.openshift.io/v1
kind: Network
metadata:
  name: cluster
spec:
```

3. Specify the advanced network configuration for your cluster in the **cluster-network-03-config.yml** file, such as in the following examples:

   Specify a different VXLAN port for the OpenShift SDN network provider

```
apiVersion: operator.openshift.io/v1
kind: Network
metadata:
  name: cluster
spec:
  defaultNetwork:
    openshiftSDNConfig:
      vxlanPort: 4800
```

   Enable IPsec for the OVN-Kubernetes network provider

```
apiVersion: operator.openshift.io/v1
kind: Network
metadata:
  name: cluster
spec:
  defaultNetwork:
    ovnKubernetesConfig:
      ipsecConfig: {}
```

4. Optional: Back up the **manifests/cluster-network-03-config.yml** file. The installation program consumes the **manifests/** directory when you create the Ignition config files.

5. Remove the Kubernetes manifest files that define the control plane machines and compute machineSets:

```
$ rm -f openshift/99_openshift-cluster-api_master-machines-*.yaml openshift/99_openshift-cluster-api_worker-machineset-*.yaml
```

   Because you create and manage these resources yourself, you do not have to initialize them.

   - You can preserve the MachineSet files to create compute machines by using the machine API, but you must update references to them to match your environment.

22.7.13. Cluster Network Operator configuration

The configuration for the cluster network is specified as part of the Cluster Network Operator (CNO) configuration and stored in a custom resource (CR) object that is named **cluster**. The CR specifies the fields for the **Network** API in the **operator.openshift.io** API group.

The CNO configuration inherits the following fields during cluster installation from the **Network** API in the **Network.config.openshift.io** API group and these fields cannot be changed:

clusterNetwork

IP address pools from which pod IP addresses are allocated.

serviceNetwork

IP address pool for services.

defaultNetwork.type

Cluster network provider, such as OpenShift SDN or OVN-Kubernetes.

You can specify the cluster network provider configuration for your cluster by setting the fields for the **defaultNetwork** object in the CNO object named **cluster**.

22.7.13.1. Cluster Network Operator configuration object

The fields for the Cluster Network Operator (CNO) are described in the following table:

Table 22.69. Cluster Network Operator configuration object

Field	Type	Description
metadata.name	**string**	The name of the CNO object. This name is always **cluster**.
spec.clusterNetwork	**array**	A list specifying the blocks of IP addresses from which pod IP addresses are allocated and the subnet prefix length assigned to each individual node in the cluster. For example: `spec:` `  clusterNetwork:` `  - cidr: 10.128.0.0/19` `  hostPrefix: 23` `  - cidr: 10.128.32.0/19` `  hostPrefix: 23` You can customize this field only in the **install-config.yaml** file before you create the manifests. The value is read-only in the manifest file.
spec.serviceNetwork	**array**	A block of IP addresses for services. The OpenShift SDN and OVN-Kubernetes Container Network Interface (CNI) network providers support only a single IP address block for the service network. For example: `spec:` `  serviceNetwork:` `  - 172.30.0.0/14` You can customize this field only in the **install-config.yaml** file before you create the manifests. The value is read-only in the manifest file.

Field	Type	Description
spec.defaultNetwork	**object**	Configures the Container Network Interface (CNI) cluster network provider for the cluster network.
spec.kubeProxyConfig	**object**	The fields for this object specify the kube-proxy configuration. If you are using the OVN-Kubernetes cluster network provider, the kube-proxy configuration has no effect.

defaultNetwork object configuration
The values for the **defaultNetwork** object are defined in the following table:

Table 22.70. **defaultNetwork** object

Field	Type	Description
type	**string**	Either **OpenShiftSDN** or **OVNKubernetes**. The cluster network provider is selected during installation. This value cannot be changed after cluster installation.  **NOTE** OpenShift Container Platform uses the OpenShift SDN Container Network Interface (CNI) cluster network provider by default.
openshiftSDNConfig	**object**	This object is only valid for the OpenShift SDN cluster network provider.
ovnKubernetesConfig	**object**	This object is only valid for the OVN-Kubernetes cluster network provider.

Configuration for the OpenShift SDN CNI cluster network provider
The following table describes the configuration fields for the OpenShift SDN Container Network Interface (CNI) cluster network provider.

Table 22.71. **openshiftSDNConfig** object

Field	Type	Description
mode	**string**	Configures the network isolation mode for OpenShift SDN. The default value is **NetworkPolicy**. The values **Multitenant** and **Subnet** are available for backwards compatibility with OpenShift Container Platform 3.x but are not recommended. This value cannot be changed after cluster installation.

Field	Type	Description
mtu	**integer**	The maximum transmission unit (MTU) for the VXLAN overlay network. This is detected automatically based on the MTU of the primary network interface. You do not normally need to override the detected MTU. If the auto-detected value is not what you expect it to be, confirm that the MTU on the primary network interface on your nodes is correct. You cannot use this option to change the MTU value of the primary network interface on the nodes. If your cluster requires different MTU values for different nodes, you must set this value to **50** less than the lowest MTU value in your cluster. For example, if some nodes in your cluster have an MTU of **9001**, and some have an MTU of**1500**, you must set this value to **1450**. This value cannot be changed after cluster installation.
vxlanPort	**integer**	The port to use for all VXLAN packets. The default value is **4789**. This value cannot be changed after cluster installation. If you are running in a virtualized environment with existing nodes that are part of another VXLAN network, then you might be required to change this. For example, when running an OpenShift SDN overlay on top of VMware NSX-T, you must select an alternate port for the VXLAN, because both SDNs use the same default VXLAN port number. On Amazon Web Services (AWS), you can select an alternate port for the VXLAN between port **9000** and port **9999**.

Example OpenShift SDN configuration

```
defaultNetwork:
  type: OpenShiftSDN
  openshiftSDNConfig:
    mode: NetworkPolicy
    mtu: 1450
    vxlanPort: 4789
```

Configuration for the OVN-Kubernetes CNI cluster network provider

The following table describes the configuration fields for the OVN-Kubernetes CNI cluster network provider.

Table 22.72. **ovnKubernetesConfig** object

Field	Type	Description

Field	Type	Description
mtu	**integer**	The maximum transmission unit (MTU) for the Geneve (Generic Network Virtualization Encapsulation) overlay network. This is detected automatically based on the MTU of the primary network interface. You do not normally need to override the detected MTU. If the auto-detected value is not what you expect it to be, confirm that the MTU on the primary network interface on your nodes is correct. You cannot use this option to change the MTU value of the primary network interface on the nodes. If your cluster requires different MTU values for different nodes, you must set this value to **100** less than the lowest MTU value in your cluster. For example, if some nodes in your cluster have an MTU of **9001**, and some have an MTU of**1500**, you must set this value to **1400**.
genevePort	**integer**	The port to use for all Geneve packets. The default value is **6081**. This value cannot be changed after cluster installation.
ipsecConfig	**object**	Specify an empty object to enable IPsec encryption.
policyAuditConfig	**object**	Specify a configuration object for customizing network policy audit logging. If unset, the defaults audit log settings are used.
gatewayConfig	**object**	Optional: Specify a configuration object for customizing how egress traffic is sent to the node gateway.  NOTE While migrating egress traffic, you can expect some disruption to workloads and service traffic until the Cluster Network Operator (CNO) successfully rolls out the changes.

Table 22.73. **policyAuditConfig** object

Field	Type	Description
rateLimit	integer	The maximum number of messages to generate every second per node. The default value is **20** messages per second.
maxFileSize	integer	The maximum size for the audit log in bytes. The default value is **50000000** or 50 MB.

Field	Type	Description
destination	string	One of the following additional audit log targets: **libc** The libc **syslog()** function of the journald process on the host. **udp:<host>:<port>** A syslog server. Replace **<host>:<port>** with the host and port of the syslog server. **unix:<file>** A Unix Domain Socket file specified by **<file>**. **null** Do not send the audit logs to any additional target.
syslogFacility	string	The syslog facility, such as **kern**, as defined by RFC5424. The default value is **local0**.

Table 22.74. **gatewayConfig** object

Field	Type	Description
routingViaHost	**boolean**	Set this field to **true** to send egress traffic from pods to the host networking stack. For highly-specialized installations and applications that rely on manually configured routes in the kernel routing table, you might want to route egress traffic to the host networking stack. By default, egress traffic is processed in OVN to exit the cluster and is not affected by specialized routes in the kernel routing table. The default value is **false**. This field has an interaction with the Open vSwitch hardware offloading feature. If you set this field to **true**, you do not receive the performance benefits of the offloading because egress traffic is processed by the host networking stack.

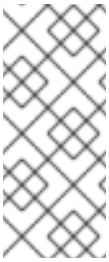
Example OVN-Kubernetes configuration with IPSec enabled

```
defaultNetwork:
  type: OVNKubernetes
  ovnKubernetesConfig:
    mtu: 1400
    genevePort: 6081
    ipsecConfig: {}
```

kubeProxyConfig object configuration

The values for the **kubeProxyConfig** object are defined in the following table:

Table 22.75. **kubeProxyConfig** object

Field	Type	Description
iptablesSyncPeriod	**string**	The refresh period for **iptables** rules. The default value is **30s**. Valid suffixes include **s**, **m**, and **h** and are described in the Go **time** package documentation.  **NOTE** Because of performance improvements introduced in OpenShift Container Platform 4.3 and greater, adjusting the **iptablesSyncPeriod** parameter is no longer necessary.
proxyArguments.iptables-min-sync-period	**array**	The minimum duration before refreshing **iptables** rules. This field ensures that the refresh does not happen too frequently. Valid suffixes include **s**, **m**, and **h** and are described in the Go **time** package. The default value is: `kubeProxyConfig:` `  proxyArguments:` `  iptables-min-sync-period:` `  - 0s`

22.7.14. Creating the Ignition config files

Because you must manually start the cluster machines, you must generate the Ignition config files that the cluster needs to make its machines.

IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

Prerequisites

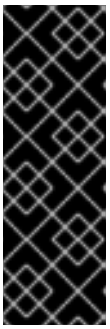
- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster. For a restricted network installation, these files are on your mirror host.

Procedure

- Obtain the Ignition config files:

```
$ ./openshift-install create ignition-configs --dir <installation_directory> 1
```

1 For **<installation_directory>**, specify the directory name to store the files that the installation program creates.



IMPORTANT

If you created an **install-config.yaml** file, specify the directory that contains it. Otherwise, specify an empty directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

The following files are generated in the directory:

```
.
├── auth
│   ├── kubeadmin-password
│   └── kubeconfig
├── bootstrap.ign
├── master.ign
├── metadata.json
└── worker.ign
```

22.7.15. Extracting the infrastructure name

The Ignition config files contain a unique cluster identifier that you can use to uniquely identify your cluster in VMware Cloud on AWS. If you plan to use the cluster identifier as the name of your virtual machine folder, you must extract it.

Prerequisites

- You obtained the OpenShift Container Platform installation program and the pull secret for your cluster.
- You generated the Ignition config files for your cluster.
- You installed the **jq** package.

Procedure

- To extract and view the infrastructure name from the Ignition config file metadata, run the following command:

```
$ jq -r .infraID <installation_directory>/metadata.json 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

Example output

```
openshift-vw9j6 1
```

1 The output of this command is your cluster name and a random string.

22.7.16. Installing RHCOS and starting the OpenShift Container Platform bootstrap process

To install OpenShift Container Platform on user-provisioned infrastructure on VMware vSphere, you must install Red Hat Enterprise Linux CoreOS (RHCOS) on vSphere hosts. When you install RHCOS, you must provide the Ignition config file that was generated by the OpenShift Container Platform installation program for the type of machine you are installing. If you have configured suitable networking, DNS, and load balancing infrastructure, the OpenShift Container Platform bootstrap process begins automatically after the RHCOS machines have rebooted.

Prerequisites

- You have obtained the Ignition config files for your cluster.
- You have access to an HTTP server that you can access from your computer and that the machines that you create can access.
- You have created a vSphere cluster.

Procedure

1. Upload the bootstrap Ignition config file, which is named **<installation_directory>/bootstrap.ign**, that the installation program created to your HTTP server. Note the URL of this file.
2. Save the following secondary Ignition config file for your bootstrap node to your computer as **<installation_directory>/merge-bootstrap.ign**:

```
{
  "ignition": {
    "config": {
      "merge": [
        {
          "source": "<bootstrap_ignition_config_url>", 1
          "verification": {}
        }
      ]
    },
    "timeouts": {},
    "version": "3.2.0"
  },
  "networkd": {},
  "passwd": {},
```

```
  "storage": {},
  "systemd": {}
}
```

1 Specify the URL of the bootstrap Ignition config file that you hosted.

When you create the virtual machine (VM) for the bootstrap machine, you use this Ignition config file.

3. Locate the following Ignition config files that the installation program created:

   - **<installation_directory>/master.ign**
   - **<installation_directory>/worker.ign**
   - **<installation_directory>/merge-bootstrap.ign**

4. Convert the Ignition config files to Base64 encoding. Later in this procedure, you must add these files to the extra configuration parameter **guestinfo.ignition.config.data** in your VM. For example, if you use a Linux operating system, you can use the **base64** command to encode the files.

```
$ base64 -w0 <installation_directory>/master.ign > <installation_directory>/master.64
```

```
$ base64 -w0 <installation_directory>/worker.ign > <installation_directory>/worker.64
```

```
$ base64 -w0 <installation_directory>/merge-bootstrap.ign > <installation_directory>/merge-bootstrap.64
```

IMPORTANT

If you plan to add more compute machines to your cluster after you finish installation, do not delete these files.

5. Obtain the RHCOS OVA image. Images are available from the RHCOS image mirror page.

IMPORTANT

The RHCOS images might not change with every release of OpenShift Container Platform. You must download an image with the highest version that is less than or equal to the OpenShift Container Platform version that you install. Use the image version that matches your OpenShift Container Platform version if it is available.

The filename contains the OpenShift Container Platform version number in the format **rhcos-vmware.<architecture>.ova**.

6. In the vSphere Client, create a folder in your datacenter to store your VMs.

   a. Click the **VMs and Templates** view.

   b. Right-click the name of your datacenter.

c. Click **New Folder → New VM and Template Folder**.

d. In the window that is displayed, enter the folder name. If you did not specify an existing folder in the **install-config.yaml** file, then create a folder with the same name as the infrastructure ID. You use this folder name so vCenter dynamically provisions storage in the appropriate location for its Workspace configuration.

7. In the vSphere Client, create a template for the OVA image and then clone the template as needed.

NOTE

In the following steps, you create a template and then clone the template for all of your cluster machines. You then provide the location for the Ignition config file for that cloned machine type when you provision the VMs.

a. From the **Hosts and Clusters** tab, right-click your cluster name and select **Deploy OVF Template**.

b. On the **Select an OVF** tab, specify the name of the RHCOS OVA file that you downloaded.

c. On the **Select a name and folder** tab, set a **Virtual machine name** for your template, such as **Template-RHCOS**. Click the name of your vSphere cluster and select the folder you created in the previous step.

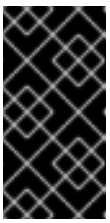
d. On the **Select a compute resource** tab, click the name of your vSphere cluster.

e. On the **Select storage** tab, configure the storage options for your VM.

- Select **Thin Provision** or **Thick Provision**, based on your storage preferences.
- Select the datastore that you specified in your **install-config.yaml** file.

f. On the **Select network** tab, specify the network that you configured for the cluster, if available.

g. When creating the OVF template, do not specify values on the **Customize template** tab or configure the template any further.



IMPORTANT

Do not start the original VM template. The VM template must remain off and must be cloned for new RHCOS machines. Starting the VM template configures the VM template as a VM on the platform, which prevents it from being used as a template that machine sets can apply configurations to.

8. Optional: Update the configured virtual hardware version in the VM template, if necessary. Follow Upgrading a virtual machine to the latest hardware version in the VMware documentation for more information.

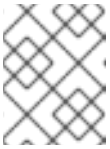
IMPORTANT

It is recommended that you update the hardware version of the VM template to version 15 before creating VMs from it, if necessary. Using hardware version 13 for your cluster nodes running on vSphere is now deprecated. If your imported template defaults to hardware version 13, you must ensure that your ESXi host is on 6.7U3 or later before upgrading the VM template to hardware version 15. If your vSphere version is less than 6.7U3, you can skip this upgrade step; however, a future version of OpenShift Container Platform is scheduled to remove support for hardware version 13 and vSphere versions less than 6.7U3.

9. After the template deploys, deploy a VM for a machine in the cluster.

   a. Right-click the template name and click **Clone → Clone to Virtual Machine**

   b. On the **Select a name and folder**tab, specify a name for the VM. You might include the machine type in the name, such as **control-plane-0** or **compute-1**.



NOTE

Ensure that all virtual machine names across a vSphere installation are unique.

   c. On the **Select a name and folder**tab, select the name of the folder that you created for the cluster.

   d. On the **Select a compute resource** tab, select the name of a host in your datacenter.

   e. On the **Select clone options**, select **Customize this virtual machine's hardware**.

   f. Optional: On the **Customize hardware** tab, click **VM Options → Advanced**.

IMPORTANT

The following configuration suggestions are for example purposes only. As a cluster administrator, you must configure resources according to the resource demands placed on your cluster. To best manage cluster resources, consider creating a resource pool from the cluster's root resource pool.

- Override default DHCP networking in vSphere. To enable static IP networking:
  - Set your static IP configuration:

```
$ export IPCFG="ip=<ip>::<gateway>:<netmask>:<hostname>:<iface>:none
nameserver=srv1 [nameserver=srv2 [nameserver=srv3 [...]]]"
```

Example command

```
$ export IPCFG="ip=192.168.100.101::192.168.100.254:255.255.255.0:::none
nameserver=8.8.8.8"
```

- Click **Edit Configuration**, and on the **Configuration Parameters** window, search the list of available parameters for steal clock accounting (**stealclock.enable**). Set the parameter to the value of **TRUE**. Enabling steal clock accounting can help with

troubleshooting cluster issues.

- Click **Add Configuration Params**. Define the following parameter names and values:
  - **disk.EnableUUID**: Specify **TRUE**.
  - **stealclock.enable**: If this parameter was not defined, add it and specify **TRUE**.
  - Create a child resource pool from the cluster's root resource pool. Perform resource allocation in this child resource pool.

g. In the **Virtual Hardware** panel of the **Customize hardware** tab, modify the specified values as required. Ensure that the amount of RAM, CPU, and disk storage meets the minimum requirements for the machine type.

h. Complete the configuration and power on the VM.

i. Check the console output to verify that Ignition ran.

Example command

```
Ignition: ran on 2022/03/14 14:48:33 UTC (this boot)
Ignition: user-provided config was applied
```

10. Create the rest of the machines for your cluster by following the preceding steps for each machine.

IMPORTANT

You must create the bootstrap and control plane machines at this time. Because some pods are deployed on compute machines by default, also create at least two compute machines before you install the cluster.

22.7.17. Adding more compute machines to a cluster in vSphere

You can add more compute machines to a user-provisioned OpenShift Container Platform cluster on VMware vSphere.

Prerequisites

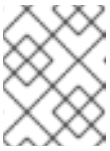
- Obtain the base64-encoded Ignition file for your compute machines.
- You have access to the vSphere template that you created for your cluster.

Procedure

1. After the template deploys, deploy a VM for a machine in the cluster.

   a. Right-click the template's name and click **Clone → Clone to Virtual Machine**

   b. On the **Select a name and folder** tab, specify a name for the VM. You might include the machine type in the name, such as **compute-1**.



NOTE

Ensure that all virtual machine names across a vSphere installation are unique.

c. On the **Select a name and folder** tab, select the name of the folder that you created for the cluster.

d. On the **Select a compute resource** tab, select the name of a host in your datacenter.

e. On the **Select clone options**, select **Customize this virtual machine's hardware**.

f. On the **Customize hardware** tab, click **VM Options → Advanced**.

- Click **Edit Configuration**, and on the **Configuration Parameters** window, click **Add Configuration Params**. Define the following parameter names and values:
  - **guestinfo.ignition.config.data**: Paste the contents of the base64-encoded compute Ignition config file for this machine type.
  - **guestinfo.ignition.config.data.encoding**: Specify **base64**.
  - **disk.EnableUUID**: Specify **TRUE**.

g. In the **Virtual Hardware** panel of the **Customize hardware** tab, modify the specified values as required. Ensure that the amount of RAM, CPU, and disk storage meets the minimum requirements for the machine type. Also, make sure to select the correct network under **Add network adapter** if there are multiple networks available.

h. Complete the configuration and power on the VM.

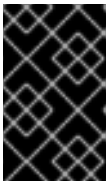
2. Continue to create more compute machines for your cluster.

22.7.18. Disk partitioning

In most cases, data partitions are originally created by installing RHCOS, rather than by installing another operating system. In such cases, the OpenShift Container Platform installer should be allowed to configure your disk partitions.

However, there are two cases where you might want to intervene to override the default partitioning when installing an OpenShift Container Platform node:

- Create separate partitions: For greenfield installations on an empty disk, you might want to add separate storage to a partition. This is officially supported for making **/var** or a subdirectory of **/var**, such as **/var/lib/etcd**, a separate partition, but not both.



IMPORTANT

For disk sizes larger than 100GB, and especially disk sizes larger than 1TB, create a separate **/var** partition. See "Creating a separate **/var** partition" and this Red Hat Knowledgebase article for more information.

IMPORTANT

Kubernetes supports only two file system partitions. If you add more than one partition to the original configuration, Kubernetes cannot monitor all of them.

- Retain existing partitions: For a brownfield installation where you are reinstalling OpenShift Container Platform on an existing node and want to retain data partitions installed from your previous operating system, there are both boot arguments and options to **coreos-installer** that allow you to retain existing data partitions.

Creating a separate /var partition

In general, disk partitioning for OpenShift Container Platform should be left to the installer. However, there are cases where you might want to create separate partitions in a part of the filesystem that you expect to grow.

OpenShift Container Platform supports the addition of a single partition to attach storage to either the **/var** partition or a subdirectory of **/var**. For example:

- **/var/lib/containers**: Holds container-related content that can grow as more images and containers are added to a system.
- **/var/lib/etcd**: Holds data that you might want to keep separate for purposes such as performance optimization of etcd storage.
- **/var**: Holds data that you might want to keep separate for purposes such as auditing.

IMPORTANT

For disk sizes larger than 100GB, and especially larger than 1TB, create a separate **/var** partition.

Storing the contents of a **/var** directory separately makes it easier to grow storage for those areas as needed and reinstall OpenShift Container Platform at a later date and keep that data intact. With this method, you will not have to pull all your containers again, nor will you have to copy massive log files when you update systems.

Because **/var** must be in place before a fresh installation of Red Hat Enterprise Linux CoreOS (RHCOS), the following procedure sets up the separate **/var** partition by creating a machine config manifest that is inserted during the **openshift-install** preparation phases of an OpenShift Container Platform installation.

Procedure

1. Create a directory to hold the OpenShift Container Platform installation files:

```
$ mkdir $HOME/clusterconfig
```

2. Run **openshift-install** to create a set of files in the **manifest** and **openshift** subdirectories. Answer the system questions as you are prompted:

```
$ openshift-install create manifests --dir $HOME/clusterconfig
? SSH Public Key ...
$ ls $HOME/clusterconfig/openshift/
99_kubeadmin-password-secret.yaml
99_openshift-cluster-api_master-machines-0.yaml
99_openshift-cluster-api_master-machines-1.yaml
99_openshift-cluster-api_master-machines-2.yaml
...
```

3. Create a Butane config that configures the additional partition. For example, name the file **$HOME/clusterconfig/98-var-partition.bu**, change the disk device name to the name of the storage device on the **worker** systems, and set the storage size as appropriate. This example places the **/var** directory on a separate partition:

```
variant: openshift
version: 4.11.0
metadata:
  labels:
    machineconfiguration.openshift.io/role: worker
  name: 98-var-partition
storage:
  disks:
  - device: /dev/<device_name> 1
    partitions:
    - label: var
      start_mib: <partition_start_offset> 2
      size_mib: <partition_size> 3
  filesystems:
    - device: /dev/disk/by-partlabel/var
      path: /var
      format: xfs
      mount_options: [defaults, prjquota] 4
      with_mount_unit: true
```

1. The storage device name of the disk that you want to partition.
2. When adding a data partition to the boot disk, a minimum value of 25000 mebibytes is recommended. The root file system is automatically resized to fill all available space up to the specified offset. If no value is specified, or if the specified value is smaller than the recommended minimum, the resulting root file system will be too small, and future reinstalls of RHCOS might overwrite the beginning of the data partition.
3. The size of the data partition in mebibytes.
4. The **prjquota** mount option must be enabled for filesystems used for container storage.

NOTE

When creating a separate **/var** partition, you cannot use different instance types for worker nodes, if the different instance types do not have the same device name.

4. Create a manifest from the Butane config and save it to the **clusterconfig/openshift** directory. For example, run the following command:

```
$ butane $HOME/clusterconfig/98-var-partition.bu -o $HOME/clusterconfig/openshift/98-var-partition.yaml
```

5. Run **openshift-install** again to create Ignition configs from a set of files in the **manifest** and **openshift** subdirectories:

```
$ openshift-install create ignition-configs --dir $HOME/clusterconfig
$ ls $HOME/clusterconfig/
auth  bootstrap.ign  master.ign  metadata.json  worker.ign
```

Now you can use the Ignition config files as input to the vSphere installation procedures to install Red Hat Enterprise Linux CoreOS (RHCOS) systems.

22.7.19. Updating the bootloader using bootupd

To update the bootloader by using **bootupd**, you must either install **bootupd** on RHCOS machines manually or provide a machine config with the enabled **systemd** unit. Unlike **grubby** or other bootloader tools, **bootupd** does not manage kernel space configuration such as passing kernel arguments.

After you have installed **bootupd**, you can manage it remotely from the OpenShift Container Platform cluster.

NOTE

It is recommended that you use **bootupd** only on bare metal or virtualized hypervisor installations, such as for protection against the BootHole vulnerability.

Manual install method

You can manually install **bootupd** by using the **bootctl** command-line tool.

1. Inspect the system status:

```
# bootupctl status
```

Example output for x86_64

```
Component EFI
  Installed: grub2-efi-x64-1:2.04-31.fc33.x86_64,shim-x64-15-8.x86_64
  Update: At latest version
```

Example output for aarch64

```
Component EFI
  Installed: grub2-efi-aa64-1:2.02-99.el8_4.1.aarch64,shim-aa64-15.4-2.el8_1.aarch64
  Update: At latest version
```

2. RHCOS images created without **bootupd** installed on them require an explicit adoption phase. If the system status is **Adoptable**, perform the adoption:

```
# bootupctl adopt-and-update
```

Example output

```
Updated: grub2-efi-x64-1:2.04-31.fc33.x86_64,shim-x64-15-8.x86_64
```

3. If an update is available, apply the update so that the changes take effect on the next reboot:

```
# bootupctl update
```

Example output

```
Updated: grub2-efi-x64-1:2.04-31.fc33.x86_64,shim-x64-15-8.x86_64
```

Machine config method

Another way to enable **bootupd** is by providing a machine config.

- Provide a machine config file with the enabled **systemd** unit, as shown in the following example:

Example output

```
variant: rhcos
version: 1.1.0
systemd:
  units:
    - name: custom-bootupd-auto.service
      enabled: true
      contents: |
        [Unit]
        Description=Bootupd automatic update

        [Service]
        ExecStart=/usr/bin/bootupctl update
        RemainAfterExit=yes

        [Install]
        WantedBy=multi-user.target
```

22.7.20. Waiting for the bootstrap process to complete

The OpenShift Container Platform bootstrap process begins after the cluster nodes first boot into the persistent RHCOS environment that has been installed to disk. The configuration information provided through the Ignition config files is used to initialize the bootstrap process and install OpenShift Container Platform on the machines. You must wait for the bootstrap process to complete.

Prerequisites

- You have created the Ignition config files for your cluster.
- You have configured suitable network, DNS and load balancing infrastructure.
- You have obtained the installation program and generated the Ignition config files for your cluster.
- You installed RHCOS on your cluster machines and provided the Ignition config files that the OpenShift Container Platform installation program generated.
- Your machines have direct internet access or have an HTTP or HTTPS proxy available.

Procedure

1. Monitor the bootstrap process:

```
$ ./openshift-install --dir <installation_directory> wait-for bootstrap-complete \ 1
    --log-level=info 2
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

Example output

```
INFO Waiting up to 30m0s for the Kubernetes API at https://api.test.example.com:6443...
INFO API v1.24.0 up
INFO Waiting up to 30m0s for bootstrapping to complete...
INFO It is now safe to remove the bootstrap resources
```

The command succeeds when the Kubernetes API server signals that it has been bootstrapped on the control plane machines.

2. After the bootstrap process is complete, remove the bootstrap machine from the load balancer.

IMPORTANT

You must remove the bootstrap machine from the load balancer at this point. You can also remove or reformat the bootstrap machine itself.

22.7.21. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

-

Example output

```
system:admin
```

22.7.22. Approving the certificate signing requests for your machines

When you add machines to a cluster, two pending certificate signing requests (CSRs) are generated for each machine that you added. You must confirm that these CSRs are approved or, if necessary, approve them yourself. The client requests must be approved first, followed by the server requests.

Prerequisites

- You added machines to your cluster.

Procedure

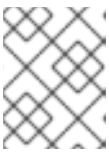
1. Confirm that the cluster recognizes the machines:

```
$ oc get nodes
```

Example output

```
NAME      STATUS    ROLES   AGE  VERSION
master-0  Ready     master  63m  v1.24.0
master-1  Ready     master  63m  v1.24.0
master-2  Ready     master  64m  v1.24.0
```

The output lists all of the machines that you created.



NOTE

The preceding output might not include the compute nodes, also known as worker nodes, until some CSRs are approved.

2. Review the pending CSRs and ensure that you see the client requests with the **Pending** or **Approved** status for each machine that you added to the cluster:

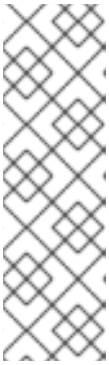
```
$ oc get csr
```

Example output

```
NAME        AGE     REQUESTOR                                                   CONDITION
csr-8b2br   15m     system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper   Pending
csr-8vnps   15m     system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper   Pending
...
```

In this example, two machines are joining the cluster. You might see more approved CSRs in the list.

3. If the CSRs were not approved, after all of the pending CSRs for the machines you added are in **Pending** status, approve the CSRs for your cluster machines:



NOTE

Because the CSRs rotate automatically, approve your CSRs within an hour of adding the machines to the cluster. If you do not approve them within an hour, the certificates will rotate, and more than two certificates will be present for each node. You must approve all of these certificates. After the client CSR is approved, the Kubelet creates a secondary CSR for the serving certificate, which requires manual approval. Then, subsequent serving certificate renewal requests are automatically approved by the **machine-approver** if the Kubelet requests a new certificate with identical parameters.

NOTE

For clusters running on platforms that are not machine API enabled, such as bare metal and other user-provisioned infrastructure, you must implement a method of automatically approving the kubelet serving certificate requests (CSRs). If a request is not approved, then the **oc exec**, **oc rsh**, and **oc logs** commands cannot succeed, because a serving certificate is required when the API server connects to the kubelet. Any operation that contacts the Kubelet endpoint requires this certificate approval to be in place. The method must watch for new CSRs, confirm that the CSR was submitted by the **node-bootstrapper** service account in the **system:node** or **system:admin** groups, and confirm the identity of the node.

- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

1 **<csr_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{{"\n"}}
{{end}}{{end}}' | xargs --no-run-if-empty oc adm certificate approve
```

NOTE

Some Operators might not become available until some CSRs are approved.

4. Now that your client requests are approved, you must review the server requests for each machine that you added to the cluster:

```
$ oc get csr
```

Example output

```
NAME        AGE     REQUESTOR                                                   CONDITION
csr-bfd72   5m26s   system:node:ip-10-0-50-126.us-east-2.compute.internal
Pending
```

```
csr-c57lv   5m26s   system:node:ip-10-0-95-157.us-east-2.compute.internal
Pending
...
```

5. If the remaining CSRs are not approved, and are in the **Pending** status, approve the CSRs for your cluster machines:

   - To approve them individually, run the following command for each valid CSR:

     ```
     $ oc adm certificate approve <csr_name> 1
     ```

     1 **<csr_name>** is the name of a CSR from the list of current CSRs.

   - To approve all pending CSRs, run the following command:

     ```
     $ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{{"\n"}}
     {{end}}{{end}}' | xargs oc adm certificate approve
     ```

6. After all client and server CSRs have been approved, the machines have the **Ready** status. Verify this by running the following command:

   ```
   $ oc get nodes
   ```

   Example output

   ```
   NAME      STATUS    ROLES   AGE  VERSION
   master-0  Ready     master  73m  v1.24.0
   master-1  Ready     master  73m  v1.24.0
   master-2  Ready     master  74m  v1.24.0
   worker-0  Ready     worker  11m  v1.24.0
   worker-1  Ready     worker  11m  v1.24.0
   ```

NOTE

It can take a few minutes after approval of the server CSRs for the machines to transition to the **Ready** status.

Additional information

- For more information on CSRs, see Certificate Signing Requests.

22.7.23. Initial Operator configuration

After the control plane initializes, you must immediately configure some Operators so that they all become available.

Prerequisites

- Your control plane has initialized.

Procedure

1. Watch the cluster components come online:

```
$ watch -n5 oc get clusteroperators
```

Example output

```
NAME                                       VERSION   AVAILABLE   PROGRESSING   DEGRADED
SINCE
authentication                             4.11.0    True        False         False      19m
baremetal                                  4.11.0    True        False         False      37m
cloud-credential                           4.11.0    True        False         False      40m
cluster-autoscaler                         4.11.0    True        False         False      37m
config-operator                            4.11.0    True        False         False      38m
console                                    4.11.0    True        False         False      26m
csi-snapshot-controller                    4.11.0    True        False         False      37m
dns                                        4.11.0    True        False         False      37m
etcd                                       4.11.0    True        False         False      36m
image-registry                             4.11.0    True        False         False      31m
ingress                                    4.11.0    True        False         False      30m
insights                                   4.11.0    True        False         False      31m
kube-apiserver                             4.11.0    True        False         False      26m
kube-controller-manager                    4.11.0    True        False         False      36m
kube-scheduler                             4.11.0    True        False         False      36m
kube-storage-version-migrator              4.11.0    True        False         False      37m
machine-api                                4.11.0    True        False         False      29m
machine-approver                           4.11.0    True        False         False      37m
machine-config                             4.11.0    True        False         False      36m
marketplace                                4.11.0    True        False         False      37m
monitoring                                 4.11.0    True        False         False      29m
network                                    4.11.0    True        False         False      38m
node-tuning                                4.11.0    True        False         False      37m
openshift-apiserver                        4.11.0    True        False         False      32m
openshift-controller-manager               4.11.0    True        False         False      30m
openshift-samples                          4.11.0    True        False         False      32m
operator-lifecycle-manager                 4.11.0    True        False         False      37m
operator-lifecycle-manager-catalog         4.11.0    True        False         False      37m
operator-lifecycle-manager-packageserver   4.11.0    True        False         False      32m
service-ca                                 4.11.0    True        False         False      38m
storage                                    4.11.0    True        False         False      37m
```

2. Configure the Operators that are not available.

22.7.23.1. Image registry removed during installation

On platforms that do not provide shareable object storage, the OpenShift Image Registry Operator bootstraps itself as **Removed**. This allows **openshift-installer** to complete installations on these platform types.

After installation, you must edit the Image Registry Operator configuration to switch the **managementState** from **Removed** to **Managed**.

22.7.23.2. Image registry storage configuration

The Image Registry Operator is not initially available for platforms that do not provide default storage. After installation, you must configure your registry to use storage so that the Registry Operator is made available.

Instructions are shown for configuring a persistent volume, which is required for production clusters. Where applicable, instructions are shown for configuring an empty directory as the storage location, which is available for only non-production clusters.

Additional instructions are provided for allowing the image registry to use block storage types by using the **Recreate** rollout strategy during upgrades.

22.7.23.2.1. Configuring block registry storage for VMware vSphere

To allow the image registry to use block storage types such as vSphere Virtual Machine Disk (VMDK) during upgrades as a cluster administrator, you can use the **Recreate** rollout strategy.

IMPORTANT

Block storage volumes are supported but not recommended for use with image registry on production clusters. An installation where the registry is configured on block storage is not highly available because the registry cannot have more than one replica.

Procedure

1. Enter the following command to set the image registry storage as a block storage type, patch the registry so that it uses the **Recreate** rollout strategy, and runs with only **1** replica:

```
$ oc patch config.imageregistry.operator.openshift.io/cluster --type=merge -p '{"spec":
{"rolloutStrategy":"Recreate","replicas":1}}'
```

2. Provision the PV for the block storage device, and create a PVC for that volume. The requested block volume uses the ReadWriteOnce (RWO) access mode.

   a. Create a **pvc.yaml** file with the following contents to define a VMware vSphere **PersistentVolumeClaim** object:

```
kind: PersistentVolumeClaim
apiVersion: v1
metadata:
  name: image-registry-storage 1
  namespace: openshift-image-registry 2
spec:
  accessModes:
  - ReadWriteOnce 3
  resources:
    requests:
      storage: 100Gi 4
```

1. A unique name that represents the **PersistentVolumeClaim** object.
2. The namespace for the **PersistentVolumeClaim** object, which is **openshift-image-registry**.
3. The access mode of the persistent volume claim. With **ReadWriteOnce**, the volume can be mounted with read and write permissions by a single node.

4 The size of the persistent volume claim.

b. Enter the following command to create the **PersistentVolumeClaim** object from the file:

```
$ oc create -f pvc.yaml -n openshift-image-registry
```

3. Enter the following command to edit the registry configuration so that it references the correct PVC:

```
$ oc edit config.imageregistry.operator.openshift.io -o yaml
```

Example output

```
storage:
  pvc:
    claim: 1
```

1 By creating a custom PVC, you can leave the **claim** field blank for the default automatic creation of an **image-registry-storage** PVC.

For instructions about configuring registry storage so that it references the correct PVC, see Configuring the registry for vSphere.

22.7.24. Completing installation on user-provisioned infrastructure

After you complete the Operator configuration, you can finish installing the cluster on infrastructure that you provide.

Prerequisites

- Your control plane has initialized.
- You have completed the initial Operator configuration.

Procedure

1. Confirm that all the cluster components are online with the following command:

```
$ watch -n5 oc get clusteroperators
```

Example output

```
NAME                                       VERSION   AVAILABLE   PROGRESSING   DEGRADED
SINCE
authentication                             4.11.0    True        False         False      19m
baremetal                                  4.11.0    True        False         False      37m
cloud-credential                           4.11.0    True        False         False      40m
cluster-autoscaler                         4.11.0    True        False         False      37m
config-operator                            4.11.0    True        False         False      38m
console                                    4.11.0    True        False         False      26m
csi-snapshot-controller                    4.11.0    True        False         False      37m
```

```
dns                                        4.11.0    True        False         False      37m
etcd                                       4.11.0    True        False         False      36m
image-registry                             4.11.0    True        False         False      31m
ingress                                    4.11.0    True        False         False      30m
insights                                   4.11.0    True        False         False      31m
kube-apiserver                             4.11.0    True        False         False      26m
kube-controller-manager                    4.11.0    True        False         False      36m
kube-scheduler                             4.11.0    True        False         False      36m
kube-storage-version-migrator              4.11.0    True        False         False      37m
machine-api                                4.11.0    True        False         False      29m
machine-approver                           4.11.0    True        False         False      37m
machine-config                             4.11.0    True        False         False      36m
marketplace                                4.11.0    True        False         False      37m
monitoring                                 4.11.0    True        False         False      29m
network                                    4.11.0    True        False         False      38m
node-tuning                                4.11.0    True        False         False      37m
openshift-apiserver                        4.11.0    True        False         False      32m
openshift-controller-manager               4.11.0    True        False         False      30m
openshift-samples                          4.11.0    True        False         False      32m
operator-lifecycle-manager                 4.11.0    True        False         False      37m
operator-lifecycle-manager-catalog         4.11.0    True        False         False      37m
operator-lifecycle-manager-packageserver   4.11.0    True        False         False      32m
service-ca                                 4.11.0    True        False         False      38m
storage                                    4.11.0    True        False         False      37m
```

Alternatively, the following command notifies you when all of the clusters are available. It also retrieves and displays credentials:

```
$ ./openshift-install --dir <installation_directory> wait-for install-complete 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

Example output

```
INFO Waiting up to 30m0s for the cluster to initialize...
```

The command succeeds when the Cluster Version Operator finishes deploying the OpenShift Container Platform cluster from Kubernetes API server.

IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

2. Confirm that the Kubernetes API server is communicating with the pods.

   a. To view a list of all pods, use the following command:

   ```
   $ oc get pods --all-namespaces
   ```

   Example output

   ```
   NAMESPACE                       NAME                                        READY   STATUS
   RESTARTS   AGE
   openshift-apiserver-operator    openshift-apiserver-operator-85cb746d55-zqhs8   1/1
   Running    1          9m
   openshift-apiserver             apiserver-67b9g                               1/1     Running     0
   3m
   openshift-apiserver             apiserver-ljcmx                               1/1     Running     0
   1m
   openshift-apiserver             apiserver-z25h4                               1/1     Running     0
   2m
   openshift-authentication-operator authentication-operator-69d5d8bf84-vh2n8        1/1
   Running    0          5m
   ...
   ```

   b. View the logs for a pod that is listed in the output of the previous command by using the following command:

   ```
   $ oc logs <pod_name> -n <namespace> 1
   ```

   1 Specify the pod name and namespace, as shown in the output of the previous command.

   If the pod logs display, the Kubernetes API server can communicate with the cluster machines.

3. For an installation with Fibre Channel Protocol (FCP), additional steps are required to enable multipathing. Do not enable multipathing during installation.
   See "Enabling multipathing with kernel arguments on RHCOS" in the *Post-installation machine configuration tasks* documentation for more information.

You can add extra compute machines after the cluster installation is completed by following Adding compute machines to vSphere.

22.7.25. Backing up VMware vSphere volumes

OpenShift Container Platform provisions new volumes as independent persistent disks to freely attach and detach the volume on any node in the cluster. As a consequence, it is not possible to back up volumes that use snapshots, or to restore volumes from snapshots. See Snapshot Limitations for more information.

Procedure

To create a backup of persistent volumes:

1. Stop the application that is using the persistent volume.
2. Clone the persistent volume.
3. Restart the application.
4. Create a backup of the cloned volume.
5. Delete the cloned volume.

22.7.26. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.11, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to OpenShift Cluster Manager Hybrid Cloud Console.

After you confirm that your OpenShift Cluster Manager Hybrid Cloud Console inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, use subscription watch to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

Additional resources

- See About remote health monitoring for more information about the Telemetry service

22.7.27. Next steps

- Customize your cluster.
- If necessary, you can opt out of remote health reporting .
- Set up your registry and configure registry storage .
- Optional: View the events from the vSphere Problem Detector Operator to determine if the cluster has permission or storage configuration issues.

22.8. INSTALLING A CLUSTER ON VMC IN A RESTRICTED NETWORK WITH USER-PROVISIONED INFRASTRUCTURE

In OpenShift Container Platform version 4.11, you can install a cluster on VMware vSphere infrastructure that you provision in a restricted network by deploying it to VMware Cloud (VMC) on AWS.

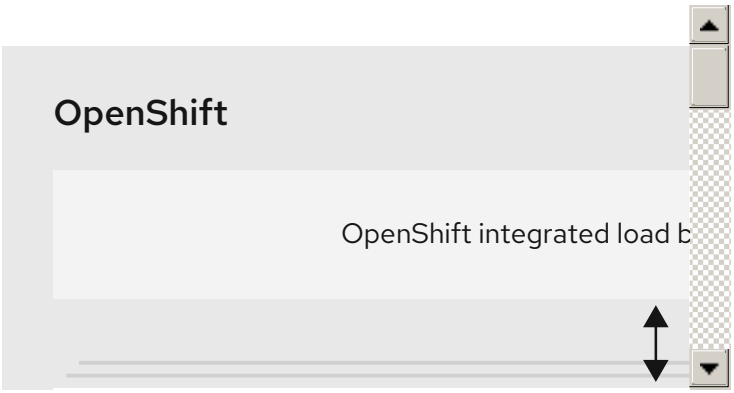
Once you configure your VMC environment for OpenShift Container Platform deployment, you use the OpenShift Container Platform installation program from the bastion management host, co-located in the VMC environment. The installation program and control plane automates the process of deploying and managing the resources needed for the OpenShift Container Platform cluster.

NOTE

OpenShift Container Platform supports deploying a cluster to a single VMware vCenter only. Deploying a cluster with machines/machine sets on multiple vCenters is not supported.

22.8.1. Setting up VMC for vSphere

You can install OpenShift Container Platform on VMware Cloud (VMC) on AWS hosted vSphere clusters to enable applications to be deployed and managed both on-premise and off-premise, across the hybrid cloud.



You must configure several options in your VMC environment prior to installing OpenShift Container Platform on VMware vSphere. Ensure your VMC environment has the following prerequisites:

- Create a non-exclusive, DHCP-enabled, NSX-T network segment and subnet. Other virtual machines (VMs) can be hosted on the subnet, but at least eight IP addresses must be available for the OpenShift Container Platform deployment.
- Configure the following firewall rules:
  - An ANY:ANY firewall rule between the installation host and the software-defined data center (SDDC) management network on port 443. This allows you to upload the Red Hat Enterprise Linux CoreOS (RHCOS) OVA during deployment.
  - An HTTPS firewall rule between the OpenShift Container Platform compute network and vCenter. This connection allows OpenShift Container Platform to communicate with vCenter for provisioning and managing nodes, persistent volume claims (PVCs), and other resources.
- You must have the following information to deploy OpenShift Container Platform:
  - The OpenShift Container Platform cluster name, such as **vmc-prod-1**.
  - The base DNS name, such as **companyname.com**.
  - If not using the default, the pod network CIDR and services network CIDR must be

identified, which are set by default to **10.128.0.0/14** and **172.30.0.0/16**, respectively. These CIDRs are used for pod-to-pod and pod-to-service communication and are not accessible externally; however, they must not overlap with existing subnets in your organization.

- The following vCenter information:
  - vCenter hostname, username, and password
  - Datacenter name, such as **SDDC-Datacenter**
  - Cluster name, such as **Cluster-1**
  - Network name
  - Datastore name, such as **WorkloadDatastore**

NOTE

It is recommended to move your vSphere cluster to the VMC **Compute-ResourcePool** resource pool after your cluster installation is finished.

- A Linux-based host deployed to VMC as a bastion.
  - The bastion host can be Red Hat Enterprise Linux (RHEL) or any another Linux-based host; it must have internet connectivity and the ability to upload an OVA to the ESXi hosts.
  - Download and install the OpenShift CLI tools to the bastion host.
    - The **openshift-install** installation program
    - The OpenShift CLI (**oc**) tool

NOTE

You cannot use the VMware NSX Container Plugin for Kubernetes (NCP), and NSX is not used as the OpenShift SDN. The version of NSX currently available with VMC is incompatible with the version of NCP certified with OpenShift Container Platform.

However, the NSX DHCP service is used for virtual machine IP management with the full-stack automated OpenShift Container Platform deployment and with nodes provisioned, either manually or automatically, by the Machine API integration with vSphere. Additionally, NSX firewall rules are created to enable access with the OpenShift Container Platform cluster and between the bastion host and the VMC vSphere hosts.

22.8.1.1. VMC Sizer tool

VMware Cloud on AWS is built on top of AWS bare metal infrastructure; this is the same bare metal infrastructure which runs AWS native services. When a VMware cloud on AWS software-defined data center (SDDC) is deployed, you consume these physical server nodes and run the VMware ESXi hypervisor in a single tenant fashion. This means the physical infrastructure is not accessible to anyone else using VMC. It is important to consider how many physical hosts you will need to host your virtual infrastructure.

To determine this, VMware provides the VMC on AWS Sizer. With this tool, you can define the resources you intend to host on VMC:

- Types of workloads
- Total number of virtual machines
- Specification information such as:
  - Storage requirements
  - vCPUs
  - vRAM
  - Overcommit ratios

With these details, the sizer tool can generate a report, based on VMware best practices, and recommend your cluster configuration and the number of hosts you will need.

22.8.2. vSphere prerequisites

- You reviewed details about the OpenShift Container Platform installation and update processes.
- You read the documentation on selecting a cluster installation method and preparing it for users.
- You created a registry on your mirror host and obtain the **imageContentSources** data for your version of OpenShift Container Platform.

IMPORTANT

Because the installation media is on the mirror host, you can use that computer to complete all installation steps.

- You provisioned block registry storage. For more information on persistent storage, see Understanding persistent storage.
- If you use a firewall and plan to use the Telemetry service, you configured the firewall to allow the sites that your cluster requires access to.

NOTE

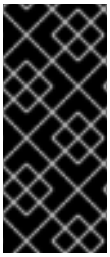
Be sure to also review this site list if you are configuring a proxy.

22.8.3. About installations in restricted networks

In OpenShift Container Platform 4.11, you can perform an installation that does not require an active connection to the internet to obtain software components. Restricted network installations can be completed using installer-provisioned infrastructure or user-provisioned infrastructure, depending on the cloud platform to which you are installing the cluster.

If you choose to perform a restricted network installation on a cloud platform, you still require access to its cloud APIs. Some cloud functions, like Amazon Web Service's Route 53 DNS and IAM services, require internet access. Depending on your network, you might require less internet access for an installation on bare metal hardware or on VMware vSphere.

To complete a restricted network installation, you must create a registry that mirrors the contents of the OpenShift image registry and contains the installation media. You can create this registry on a mirror host, which can access both the internet and your closed network, or by using other methods that meet your restrictions.



IMPORTANT

Because of the complexity of the configuration for user-provisioned installations, consider completing a standard user-provisioned infrastructure installation before you attempt a restricted network installation using user-provisioned infrastructure. Completing this test installation might make it easier to isolate and troubleshoot any issues that might arise during your installation in a restricted network.

22.8.3.1. Additional limits

Clusters in restricted networks have the following additional limitations and restrictions:

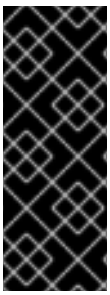
- The **ClusterVersion** status includes an **Unable to retrieve available updates** error.
- By default, you cannot use the contents of the Developer Catalog because you cannot access the required image stream tags.

22.8.4. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.11, you require access to the internet to obtain the images that are necessary to install your cluster.

You must have internet access to:

- Access OpenShift Cluster Manager Hybrid Cloud Console to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access Quay.io to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.



IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

22.8.5. VMware vSphere infrastructure requirements

You must install the OpenShift Container Platform cluster on a VMware vSphere version 7 instance that meets the requirements for the components that you use.

NOTE

OpenShift Container Platform version 4.11 does not support VMware vSphere version 8.0.

You can host the VMware vSphere infrastructure on-premise or on a VMware Cloud Verified provider that meets the requirements outlined in the following table:

Table 22.76. Version requirements for vSphere virtual environments

Virtual environment product	Required version
VM hardware version	15 or later
vSphere ESXi hosts	7
vCenter host	7

IMPORTANT

Installing a cluster on VMware vSphere version 7.0 Update 1 or earlier is now deprecated. These versions are still fully supported, but version 4.11 of OpenShift Container Platform requires vSphere virtual hardware version 15 or later. Hardware version 15 is now the default for vSphere virtual machines in OpenShift Container Platform. To update the hardware version for your vSphere nodes, see the "Updating hardware on nodes running in vSphere" article.

If your vSphere nodes are below hardware version 15 or your VMware vSphere version is earlier than 6.7.3, upgrading from OpenShift Container Platform 4.10 to OpenShift Container Platform 4.11 is not available.

Table 22.77. Minimum supported vSphere version for VMware components

Component	Minimum supported versions	Description
Hypervisor	vSphere 7 with HW version 15	This version is the minimum version that Red Hat Enterprise Linux CoreOS (RHCOS) supports. For more information about supported hardware on the latest version of Red Hat Enterprise Linux (RHEL) that is compatible with RHCOS, see Hardware on the Red Hat Customer Portal.
Storage with in-tree drivers	vSphere 7	This plugin creates vSphere storage by using the in-tree storage drivers for vSphere included in OpenShift Container Platform.

IMPORTANT

You must ensure that the time on your ESXi hosts is synchronized before you install OpenShift Container Platform. See Edit Time Configuration for a Host in the VMware documentation.

22.8.6. VMware vSphere CSI Driver Operator requirements

To install the vSphere CSI Driver Operator, the following requirements must be met:

- VMware vSphere version 7.0 Update 1 or later
- Virtual machines of hardware version 15 or later
- No third-party vSphere CSI driver already installed in the cluster

IMPORTANT

If a third-party vSphere CSI driver is present in the cluster, OpenShift Container Platform does not overwrite it. If you continue with the third-party vSphere CSI driver when upgrading to the next major version of OpenShift Container Platform, the **oc** CLI prompts you with the following message:

```
VSphereCSIDriverOperatorCRUpgradeable: VMwareVSphereControllerUpgradeable:
found existing unsupported csi.vsphere.vmware.com driver
```

The previous message informs you that Red Hat does not support the third-party vSphere CSI driver during an OpenShift Container Platform upgrade operation. You can choose to ignore this message and continue with the upgrade operation.

Additional resources

- To remove a third-party CSI driver, see Removing a third-party vSphere CSI Driver .
- To update the hardware version for your vSphere nodes, see Updating hardware on nodes running in vSphere.

22.8.7. Requirements for a cluster with user-provisioned infrastructure

For a cluster that contains user-provisioned infrastructure, you must deploy all of the required machines.

This section describes the requirements for deploying OpenShift Container Platform on user-provisioned infrastructure.

22.8.7.1. Required machines for cluster installation

The smallest OpenShift Container Platform clusters require the following hosts:

Table 22.78. Minimum required hosts

Hosts	Description

Hosts	Description
One temporary bootstrap machine	The cluster requires the bootstrap machine to deploy the OpenShift Container Platform cluster on the three control plane machines. You can remove the bootstrap machine after you install the cluster.
Three control plane machines	The control plane machines run the Kubernetes and OpenShift Container Platform services that form the control plane.
At least two compute machines, which are also known as worker machines.	The workloads requested by OpenShift Container Platform users run on the compute machines.

IMPORTANT

To maintain high availability of your cluster, use separate physical hosts for these cluster machines.

The bootstrap and control plane machines must use Red Hat Enterprise Linux CoreOS (RHCOS) as the operating system. However, the compute machines can choose between Red Hat Enterprise Linux CoreOS (RHCOS), Red Hat Enterprise Linux (RHEL) 8.6 and later.

Note that RHCOS is based on Red Hat Enterprise Linux (RHEL) 8 and inherits all of its hardware certifications and requirements. See Red Hat Enterprise Linux technology capabilities and limits .

22.8.7.2. Minimum resource requirements for cluster installation

Each cluster machine must meet the following minimum requirements:

Table 22.79. Minimum resource requirements

Machine	Operating System	vCPU [1]	Virtual RAM	Storage	IOPS [2]
Bootstrap	RHCOS	4	16 GB	100 GB	300
Control plane	RHCOS	4	16 GB	100 GB	300
Compute	RHCOS, RHEL 8.6 and later [3]	2	8 GB	100 GB	300

1. One vCPU is equivalent to one physical core when simultaneous multithreading (SMT), or hyperthreading, is not enabled. When enabled, use the following formula to calculate the corresponding ratio: (threads per core × cores) × sockets = vCPUs.

2. OpenShift Container Platform and Kubernetes are sensitive to disk performance, and faster storage is recommended, particularly for etcd on the control plane nodes which require a 10 ms p99 fsync duration. Note that on many cloud platforms, storage size and IOPS scale together, so

you might need to over-allocate storage volume to obtain sufficient performance.

3. As with all user-provisioned installations, if you choose to use RHEL compute machines in your cluster, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks. Use of RHEL 7 compute machines is deprecated and has been removed in OpenShift Container Platform 4.10 and later.

If an instance type for your platform meets the minimum requirements for cluster machines, it is supported to use in OpenShift Container Platform.

22.8.7.3. Certificate signing requests management

Because your cluster has limited access to automatic machine management when you use infrastructure that you provision, you must provide a mechanism for approving cluster certificate signing requests (CSRs) after installation. The **kube-controller-manager** only approves the kubelet client CSRs. The **machine-approver** cannot guarantee the validity of a serving certificate that is requested by using kubelet credentials because it cannot confirm that the correct machine issued the request. You must determine and implement a method of verifying the validity of the kubelet serving certificate requests and approving them.

22.8.7.4. Networking requirements for user-provisioned infrastructure

All the Red Hat Enterprise Linux CoreOS (RHCOS) machines require networking to be configured in **initramfs** during boot to fetch their Ignition config files.

During the initial boot, the machines require an IP address configuration that is set either through a DHCP server or statically by providing the required boot options. After a network connection is established, the machines download their Ignition config files from an HTTP or HTTPS server. The Ignition config files are then used to set the exact state of each machine. The Machine Config Operator completes more changes to the machines, such as the application of new certificates or keys, after installation.

It is recommended to use a DHCP server for long-term management of the cluster machines. Ensure that the DHCP server is configured to provide persistent IP addresses, DNS server information, and hostnames to the cluster machines.

NOTE

If a DHCP service is not available for your user-provisioned infrastructure, you can instead provide the IP networking configuration and the address of the DNS server to the nodes at RHCOS install time. These can be passed as boot arguments if you are installing from an ISO image. See the *Installing RHCOS and starting the OpenShift Container Platform bootstrap process* section for more information about static IP provisioning and advanced networking options.

The Kubernetes API server must be able to resolve the node names of the cluster machines. If the API servers and worker nodes are in different zones, you can configure a default DNS search zone to allow the API server to resolve the node names. Another supported approach is to always refer to hosts by their fully-qualified domain names in both the node objects and all DNS requests.

22.8.7.4.1. Setting the cluster node hostnames through DHCP

On Red Hat Enterprise Linux CoreOS (RHCOS) machines, the hostname is set through NetworkManager. By default, the machines obtain their hostname through DHCP. If the hostname is not

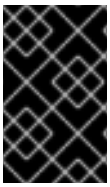
provided by DHCP, set statically through kernel arguments, or another method, it is obtained through a reverse DNS lookup. Reverse DNS lookup occurs after the network has been initialized on a node and can take time to resolve. Other system services can start prior to this and detect the hostname as **localhost** or similar. You can avoid this by using DHCP to provide the hostname for each cluster node.

Additionally, setting the hostnames through DHCP can bypass any manual DNS record name configuration errors in environments that have a DNS split-horizon implementation.

22.8.7.4.2. Network connectivity requirements

You must configure the network connectivity between machines to allow OpenShift Container Platform cluster components to communicate. Each machine must be able to resolve the hostnames of all other machines in the cluster.

This section provides details about the ports that are required.



IMPORTANT

In connected OpenShift Container Platform environments, all nodes are required to have internet access to pull images for platform containers and provide telemetry data to Red Hat.

Table 22.80. Ports used for all-machine to all-machine communications

Protocol	Port	Description
ICMP	N/A	Network reachability tests
TCP	**1936**	Metrics
	9000-**9999**	Host level services, including the node exporter on ports **9100**-**9101** and the Cluster Version Operator on port**9099**.
	10250-**10259**	The default ports that Kubernetes reserves
	10256	openshift-sdn
UDP	**4789**	VXLAN
	6081	Geneve
	9000-**9999**	Host level services, including the node exporter on ports **9100**-**9101**.
	500	IPsec IKE packets
	4500	IPsec NAT-T packets
TCP/UDP	**30000**-**32767**	Kubernetes node port

Protocol	Port	Description
ESP	N/A	IPsec Encapsulating Security Payload (ESP)

Table 22.81. Ports used for all-machine to control plane communications

Protocol	Port	Description
TCP	**6443**	Kubernetes API

Table 22.82. Ports used for control plane machine to control plane machine communications

Protocol	Port	Description
TCP	**2379-2380**	etcd server and peer ports

Ethernet adaptor hardware address requirements
When provisioning VMs for the cluster, the ethernet interfaces configured for each VM must use a MAC address from the VMware Organizationally Unique Identifier (OUI) allocation ranges:

- **00:05:69:00:00:00** to **00:05:69:FF:FF:FF**
- **00:0c:29:00:00:00** to **00:0c:29:FF:FF:FF**
- **00:1c:14:00:00:00** to **00:1c:14:FF:FF:FF**
- **00:50:56:00:00:00** to **00:50:56:3F:FF:FF**

If a MAC address outside the VMware OUI is used, the cluster installation will not succeed.

NTP configuration for user-provisioned infrastructure
OpenShift Container Platform clusters are configured to use a public Network Time Protocol (NTP) server by default. If you want to use a local enterprise NTP server, or if your cluster is being deployed in a disconnected network, you can configure the cluster to use a specific time server. For more information, see the documentation for *Configuring chrony time service* .

If a DHCP server provides NTP server information, the chrony time service on the Red Hat Enterprise Linux CoreOS (RHCOS) machines read the information and can sync the clock with the NTP servers.

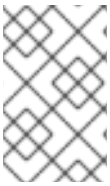
22.8.7.5. User-provisioned DNS requirements

In OpenShift Container Platform deployments, DNS name resolution is required for the following components:

- The Kubernetes API
- The OpenShift Container Platform application wildcard
- The bootstrap, control plane, and compute machines

Reverse DNS resolution is also required for the Kubernetes API, the bootstrap machine, the control plane machines, and the compute machines.

DNS A/AAAA or CNAME records are used for name resolution and PTR records are used for reverse name resolution. The reverse records are important because Red Hat Enterprise Linux CoreOS (RHCOS) uses the reverse records to set the hostnames for all the nodes, unless the hostnames are provided by DHCP. Additionally, the reverse records are used to generate the certificate signing requests (CSR) that OpenShift Container Platform needs to operate.

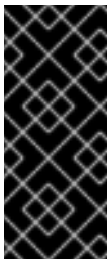


NOTE

It is recommended to use a DHCP server to provide the hostnames to each cluster node. See the *DHCP recommendations for user-provisioned infrastructure* section for more information.

The following DNS records are required for a user-provisioned OpenShift Container Platform cluster and they must be in place before installation. In each record, **<cluster_name>** is the cluster name and **<base_domain>** is the base domain that you specify in the **install-config.yaml** file. A complete DNS record takes the form: **<component>.<cluster_name>.<base_domain>.**.

Table 22.83. Required DNS records

Component	Record	Description
Kubernetes API	**api.<cluster_name>.<base_domain>.**	A DNS A/AAAA or CNAME record, and a DNS PTR record, to identify the API load balancer. These records must be resolvable by both clients external to the cluster and from all the nodes within the cluster.
	api-int.<cluster_name>.<base_domain>.	A DNS A/AAAA or CNAME record, and a DNS PTR record, to internally identify the API load balancer. These records must be resolvable from all the nodes within the cluster.  IMPORTANT The API server must be able to resolve the worker nodes by the hostnames that are recorded in Kubernetes. If the API server cannot resolve the node names, then proxied API calls can fail, and you cannot retrieve logs from pods.
Routes	***.apps.<cluster_name>.<base_domain>.**	A wildcard DNS A/AAAA or CNAME record that refers to the application ingress load balancer. The application ingress load balancer targets the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default. These records must be resolvable by both clients external to the cluster and from all the nodes within the cluster. For example, **console-openshift-console.apps.<cluster_name>.<base_domain>** is used as a wildcard route to the OpenShift Container Platform console.

Component	Record	Description
Bootstrap machine	**bootstrap.<cluster_name>.<base_domain>.**	A DNS A/AAAA or CNAME record, and a DNS PTR record, to identify the bootstrap machine. These records must be resolvable by the nodes within the cluster.
Control plane machines	**<master><n>.<cluster_name>.<base_domain>.**	DNS A/AAAA or CNAME records and DNS PTR records to identify each machine for the control plane nodes. These records must be resolvable by the nodes within the cluster.
Compute machines	**<worker><n>.<cluster_name>.<base_domain>.**	DNS A/AAAA or CNAME records and DNS PTR records to identify each machine for the worker nodes. These records must be resolvable by the nodes within the cluster.

NOTE

In OpenShift Container Platform 4.4 and later, you do not need to specify etcd host and SRV records in your DNS configuration.

TIP

You can use the **dig** command to verify name and reverse name resolution. See the section on *Validating DNS resolution for user-provisioned infrastructure* for detailed validation steps.

22.8.7.5.1. Example DNS configuration for user-provisioned clusters

This section provides A and PTR record configuration samples that meet the DNS requirements for deploying OpenShift Container Platform on user-provisioned infrastructure. The samples are not meant to provide advice for choosing one DNS solution over another.

In the examples, the cluster name is **ocp4** and the base domain is **example.com**.

Example DNS A record configuration for a user-provisioned cluster

The following example is a BIND zone file that shows sample A records for name resolution in a user-provisioned cluster.

Example 22.19. Sample DNS zone database

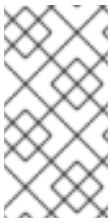
```
$TTL 1W
@ IN SOA ns1.example.com. root (
  2019070700 ; serial
  3H  ; refresh (3 hours)
  30M  ; retry (30 minutes)
  2W  ; expiry (2 weeks)
  1W )  ; minimum (1 week)
 IN NS ns1.example.com.
 IN MX 10 smtp.example.com.
```

```
;
;
ns1.example.com.  IN A 192.168.1.5
smtp.example.com.  IN A 192.168.1.5
;
helper.example.com.  IN A 192.168.1.5
helper.ocp4.example.com. IN A 192.168.1.5
;
api.ocp4.example.com.  IN A 192.168.1.5 1
api-int.ocp4.example.com. IN A 192.168.1.5 2
;
*.apps.ocp4.example.com. IN A 192.168.1.5 3
;
bootstrap.ocp4.example.com. IN A 192.168.1.96 4
;
master0.ocp4.example.com. IN A 192.168.1.97 5
master1.ocp4.example.com. IN A 192.168.1.98 6
master2.ocp4.example.com. IN A 192.168.1.99 7
;
worker0.ocp4.example.com. IN A 192.168.1.11 8
worker1.ocp4.example.com. IN A 192.168.1.7 9
;
;EOF
```

1 Provides name resolution for the Kubernetes API. The record refers to the IP address of the API load balancer.

2 Provides name resolution for the Kubernetes API. The record refers to the IP address of the API load balancer and is used for internal cluster communications.

3 Provides name resolution for the wildcard routes. The record refers to the IP address of the application ingress load balancer. The application ingress load balancer targets the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.



NOTE

In the example, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

4 Provides name resolution for the bootstrap machine.

5 6 7 Provides name resolution for the control plane machines.

8 9 Provides name resolution for the compute machines.

Example DNS PTR record configuration for a user-provisioned cluster

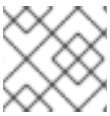
The following example BIND zone file shows sample PTR records for reverse name resolution in a user-provisioned cluster.

```
-
```

Example 22.20. Sample DNS zone database for reverse records

```
$TTL 1W
@ IN SOA ns1.example.com. root (
  2019070700 ; serial
  3H  ; refresh (3 hours)
  30M  ; retry (30 minutes)
  2W  ; expiry (2 weeks)
  1W )  ; minimum (1 week)
 IN NS ns1.example.com.
;
5.1.168.192.in-addr.arpa. IN PTR api.ocp4.example.com. 1
5.1.168.192.in-addr.arpa. IN PTR api-int.ocp4.example.com. 2
;
96.1.168.192.in-addr.arpa. IN PTR bootstrap.ocp4.example.com. 3
;
97.1.168.192.in-addr.arpa. IN PTR master0.ocp4.example.com. 4
98.1.168.192.in-addr.arpa. IN PTR master1.ocp4.example.com. 5
99.1.168.192.in-addr.arpa. IN PTR master2.ocp4.example.com. 6
;
11.1.168.192.in-addr.arpa. IN PTR worker0.ocp4.example.com. 7
7.1.168.192.in-addr.arpa. IN PTR worker1.ocp4.example.com. 8
;
;EOF
```

1. Provides reverse DNS resolution for the Kubernetes API. The PTR record refers to the record name of the API load balancer.
2. Provides reverse DNS resolution for the Kubernetes API. The PTR record refers to the record name of the API load balancer and is used for internal cluster communications.
3. Provides reverse DNS resolution for the bootstrap machine.
4. 5. 6. Provides reverse DNS resolution for the control plane machines.
7. 8. Provides reverse DNS resolution for the compute machines.



NOTE

A PTR record is not required for the OpenShift Container Platform application wildcard.

22.8.7.6. Load balancing requirements for user-provisioned infrastructure

Before you install OpenShift Container Platform, you must provision the API and application ingress load balancing infrastructure. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

NOTE

If you want to deploy the API and application Ingress load balancers with a Red Hat Enterprise Linux (RHEL) instance, you must purchase the RHEL subscription separately.

The load balancing infrastructure must meet the following requirements:

1. **API load balancer**: Provides a common endpoint for users, both human and machine, to interact with and configure the platform. Configure the following conditions:

   - Layer 4 load balancing only. This can be referred to as Raw TCP, SSL Passthrough, or SSL Bridge mode. If you use SSL Bridge mode, you must enable Server Name Indication (SNI) for the API routes.

   - A stateless load balancing algorithm. The options vary based on the load balancer implementation.

IMPORTANT

Do not configure session persistence for an API load balancer. Configuring session persistence for a Kubernetes API server might cause performance issues from excess application traffic for your OpenShift Container Platform cluster and the Kubernetes API that runs inside the cluster.

Configure the following ports on both the front and back of the load balancers:

Table 22.84. API load balancer

Port	Back-end machines (pool members)	Internal	External	Description
6443	Bootstrap and control plane. You remove the bootstrap machine from the load balancer after the bootstrap machine initializes the cluster control plane. You must configure the **/readyz** endpoint for the API server health check probe.	X	X	Kubernetes API server
22623	Bootstrap and control plane. You remove the bootstrap machine from the load balancer after the bootstrap machine initializes the cluster control plane.	X		Machine config server

NOTE

The load balancer must be configured to take a maximum of 30 seconds from the time the API server turns off the **/readyz** endpoint to the removal of the API server instance from the pool. Within the time frame after **/readyz** returns an error or becomes healthy, the endpoint must have been removed or added. Probing every 5 or 10 seconds, with two successful requests to become healthy and three to become unhealthy, are well-tested values.

2. **Application Ingress load balancer**: Provides an ingress point for application traffic flowing in from outside the cluster. A working configuration for the Ingress router is required for an OpenShift Container Platform cluster.
   Configure the following conditions:

- Layer 4 load balancing only. This can be referred to as Raw TCP, SSL Passthrough, or SSL Bridge mode. If you use SSL Bridge mode, you must enable Server Name Indication (SNI) for the ingress routes.
- A connection-based or session-based persistence is recommended, based on the options available and types of applications that will be hosted on the platform.

TIP

If the true IP address of the client can be seen by the application Ingress load balancer, enabling source IP-based session persistence can improve performance for applications that use end-to-end TLS encryption.

Configure the following ports on both the front and back of the load balancers:

Table 22.85. Application Ingress load balancer

Port	Back-end machines (pool members)	Internal	External	Description
443	The machines that run the Ingress Controller pods, compute, or worker, by default.	X	X	HTTPS traffic
80	The machines that run the Ingress Controller pods, compute, or worker, by default.	X	X	HTTP traffic

NOTE

If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application Ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes.

22.8.7.6.1. Example load balancer configuration for user-provisioned clusters

This section provides an example API and application ingress load balancer configuration that meets the load balancing requirements for user-provisioned clusters. The sample is an **/etc/haproxy/haproxy.cfg** configuration for an HAProxy load balancer. The example is not meant to provide advice for choosing one load balancing solution over another.

In the example, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

NOTE

If you are using HAProxy as a load balancer and SELinux is set to **enforcing**, you must ensure that the HAProxy service can bind to the configured TCP port by running **setsebool -P haproxy_connect_any=1**.

Example 22.21. Sample API and application Ingress load balancer configuration

```
global
  log         127.0.0.1 local2
  pidfile     /var/run/haproxy.pid
  maxconn     4000
  daemon
defaults
  mode                    http
  log                     global
  option                  dontlognull
  option http-server-close
  option                  redispatch
  retries                 3
  timeout http-request    10s
  timeout queue           1m
  timeout connect         10s
  timeout client          1m
  timeout server          1m
  timeout http-keep-alive 10s
  timeout check           10s
  maxconn                 3000
listen api-server-6443 (1)
  bind *:6443
  mode tcp
  server bootstrap bootstrap.ocp4.example.com:6443 check inter 1s backup (2)
  server master0 master0.ocp4.example.com:6443 check inter 1s
  server master1 master1.ocp4.example.com:6443 check inter 1s
  server master2 master2.ocp4.example.com:6443 check inter 1s
listen machine-config-server-22623 (3)
  bind *:22623
  mode tcp
  option  httpchk GET /readyz HTTP/1.0
  option  log-health-checks
  balance roundrobin
  server bootstrap bootstrap.ocp4.example.com:6443 verify none check check-ssl inter 10s fall 2
rise 3 backup (4)
  server master0 master0.ocp4.example.com:6443 weight 1 verify none check check-ssl inter 10s
fall 2 rise 3
  server master1 master1.ocp4.example.com:6443 weight 1 verify none check check-ssl inter 10s
fall 2 rise 3
  server master2 master2.ocp4.example.com:6443 weight 1 verify none check check-ssl inter 10s
fall 2 rise 3
listen ingress-router-443 (5)
  bind *:443
  mode tcp
  balance source
  server worker0 worker0.ocp4.example.com:443 check inter 1s
  server worker1 worker1.ocp4.example.com:443 check inter 1s
listen ingress-router-80 (6)
  bind *:80
  mode tcp
  balance source
  server worker0 worker0.ocp4.example.com:80 check inter 1s
  server worker1 worker1.ocp4.example.com:80 check inter 1s
```

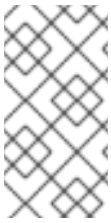
(1) Port **6443** handles the Kubernetes API traffic and points to the control plane machines.

2 4 The bootstrap entries must be in place before the OpenShift Container Platform cluster installation and they must be removed after the bootstrap process is complete.

3 Port **22623** handles the machine config server traffic and points to the control plane machines.

5 Port **443** handles the HTTPS traffic and points to the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.

6 Port **80** handles the HTTP traffic and points to the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.



NOTE

If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application Ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes.

TIP

If you are using HAProxy as a load balancer, you can check that the **haproxy** process is listening on ports **6443**, **22623**, **443**, and **80** by running **netstat -nltupe** on the HAProxy node.

22.8.8. Preparing the user-provisioned infrastructure

Before you install OpenShift Container Platform on user-provisioned infrastructure, you must prepare the underlying infrastructure.

This section provides details about the high-level steps required to set up your cluster infrastructure in preparation for an OpenShift Container Platform installation. This includes configuring IP networking and network connectivity for your cluster nodes, enabling the required ports through your firewall, and setting up the required DNS and load balancing infrastructure.

After preparation, your cluster infrastructure must meet the requirements outlined in the *Requirements for a cluster with user-provisioned infrastructure* section.

Prerequisites

- You have reviewed the OpenShift Container Platform 4.x Tested Integrations page.
- You have reviewed the infrastructure requirements detailed in the *Requirements for a cluster with user-provisioned infrastructure* section.

Procedure

1. If you are using DHCP to provide the IP networking configuration to your cluster nodes, configure your DHCP service.
   a. Add persistent IP addresses for the nodes to your DHCP server configuration. In your configuration, match the MAC address of the relevant network interface to the intended IP address for each node.

b. When you use DHCP to configure IP addressing for the cluster machines, the machines also obtain the DNS server information through DHCP. Define the persistent DNS server address that is used by the cluster nodes through your DHCP server configuration.

NOTE

If you are not using a DHCP service, you must provide the IP networking configuration and the address of the DNS server to the nodes at RHCOS install time. These can be passed as boot arguments if you are installing from an ISO image. See the *Installing RHCOS and starting the OpenShift Container Platform bootstrap process* section for more information about static IP provisioning and advanced networking options.

c. Define the hostnames of your cluster nodes in your DHCP server configuration. See the *Setting the cluster node hostnames through DHCP* section for details about hostname considerations.

NOTE

If you are not using a DHCP service, the cluster nodes obtain their hostname through a reverse DNS lookup.

2. Ensure that your network infrastructure provides the required network connectivity between the cluster components. See the *Networking requirements for user-provisioned infrastructure* section for details about the requirements.

3. Configure your firewall to enable the ports required for the OpenShift Container Platform cluster components to communicate. See *Networking requirements for user-provisioned infrastructure* section for details about the ports that are required.

IMPORTANT

By default, port **1936** is accessible for an OpenShift Container Platform cluster, because each control plane node needs access to this port.

Avoid using the Ingress load balancer to expose this port, because doing so might result in the exposure of sensitive information, such as statistics and metrics, related to Ingress Controllers.

4. Setup the required DNS infrastructure for your cluster.

   a. Configure DNS name resolution for the Kubernetes API, the application wildcard, the bootstrap machine, the control plane machines, and the compute machines.

   b. Configure reverse DNS resolution for the Kubernetes API, the bootstrap machine, the control plane machines, and the compute machines.
   See the *User-provisioned DNS requirements* section for more information about the OpenShift Container Platform DNS requirements.

5. Validate your DNS configuration.

   a. From your installation node, run DNS lookups against the record names of the Kubernetes API, the wildcard routes, and the cluster nodes. Validate that the IP addresses in the responses correspond to the correct components.

b. From your installation node, run reverse DNS lookups against the IP addresses of the load balancer and the cluster nodes. Validate that the record names in the responses correspond to the correct components.
See the *Validating DNS resolution for user-provisioned infrastructure* section for detailed DNS validation steps.

6. Provision the required API and application ingress load balancing infrastructure. See the *Load balancing requirements for user-provisioned infrastructure* section for more information about the requirements.

NOTE

Some load balancing solutions require the DNS name resolution for the cluster nodes to be in place before the load balancing is initialized.

22.8.9. Validating DNS resolution for user-provisioned infrastructure

You can validate your DNS configuration before installing OpenShift Container Platform on user-provisioned infrastructure.

IMPORTANT

The validation steps detailed in this section must succeed before you install your cluster.

Prerequisites

- You have configured the required DNS records for your user-provisioned infrastructure.

Procedure

1. From your installation node, run DNS lookups against the record names of the Kubernetes API, the wildcard routes, and the cluster nodes. Validate that the IP addresses contained in the responses correspond to the correct components.

   a. Perform a lookup against the Kubernetes API record name. Check that the result points to the IP address of the API load balancer:

   ```
   $ dig +noall +answer @<nameserver_ip> api.<cluster_name>.<base_domain>
   ```
   (1)

   (1) Replace **<nameserver_ip>** with the IP address of the nameserver, **<cluster_name>** with your cluster name, and **<base_domain>** with your base domain name.

   Example output

   ```
   api.ocp4.example.com.  604800 IN A 192.168.1.5
   ```

   b. Perform a lookup against the Kubernetes internal API record name. Check that the result points to the IP address of the API load balancer:

   ```
   $ dig +noall +answer @<nameserver_ip> api-int.<cluster_name>.<base_domain>
   ```

   Example output

```
api-int.ocp4.example.com.  604800 IN A 192.168.1.5
```

c. Test an example ***.apps.<cluster_name>.<base_domain>*** DNS wildcard lookup. All of the application wildcard lookups must resolve to the IP address of the application ingress load balancer:

```
$ dig +noall +answer @<nameserver_ip> random.apps.<cluster_name>.<base_domain>
```

Example output

```
random.apps.ocp4.example.com.  604800 IN A 192.168.1.5
```

NOTE

In the example outputs, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

You can replace **random** with another wildcard value. For example, you can query the route to the OpenShift Container Platform console:

```
$ dig +noall +answer @<nameserver_ip> console-openshift-console.apps.
<cluster_name>.<base_domain>
```

Example output

```
console-openshift-console.apps.ocp4.example.com. 604800 IN A 192.168.1.5
```

d. Run a lookup against the bootstrap DNS record name. Check that the result points to the IP address of the bootstrap node:

```
$ dig +noall +answer @<nameserver_ip> bootstrap.<cluster_name>.<base_domain>
```

Example output

```
bootstrap.ocp4.example.com.  604800 IN A 192.168.1.96
```

e. Use this method to perform lookups against the DNS record names for the control plane and compute nodes. Check that the results correspond to the IP addresses of each node.

2. From your installation node, run reverse DNS lookups against the IP addresses of the load balancer and the cluster nodes. Validate that the record names contained in the responses correspond to the correct components.

a. Perform a reverse lookup against the IP address of the API load balancer. Check that the response includes the record names for the Kubernetes API and the Kubernetes internal API:

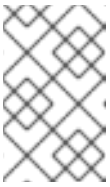
```
$ dig +noall +answer @<nameserver_ip> -x 192.168.1.5
```

Example output

```
5.1.168.192.in-addr.arpa. 604800 IN PTR api-int.ocp4.example.com. 1
5.1.168.192.in-addr.arpa. 604800 IN PTR api.ocp4.example.com. 2
```

1 Provides the record name for the Kubernetes internal API.

2 Provides the record name for the Kubernetes API.



NOTE

A PTR record is not required for the OpenShift Container Platform application wildcard. No validation step is needed for reverse DNS resolution against the IP address of the application ingress load balancer.

b. Perform a reverse lookup against the IP address of the bootstrap node. Check that the result points to the DNS record name of the bootstrap node:

```
$ dig +noall +answer @<nameserver_ip> -x 192.168.1.96
```

Example output

```
96.1.168.192.in-addr.arpa. 604800 IN PTR bootstrap.ocp4.example.com.
```

c. Use this method to perform reverse lookups against the IP addresses for the control plane and compute nodes. Check that the results correspond to the DNS record names of each node.

22.8.10. Generating a key pair for cluster node SSH access

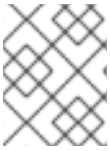
During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the **~/.ssh/authorized_keys** list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The **./openshift-install gather** command also requires the SSH public key to be in place on the cluster nodes.

IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.



NOTE

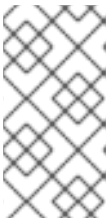
You must use a local key, not one that you configured with platform-specific approaches such as AWS key pairs.

Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N '' -f <path>/<file_name> 1
```

1 Specify the path and file name, such as ~/**.ssh/id_ed25519**, of the new SSH key. If you have an existing key pair, ensure your public key is in the your ~/**.ssh** directory.



NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS validated or Modules In Process cryptographic libraries on the **x86_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

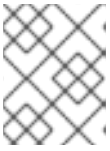
2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the ~/**.ssh/id_ed25519.pub** public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the **./openshift-install gather** command.



NOTE

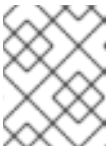
On some distributions, default SSH private key identities such as ~/**.ssh/id_rsa** and ~/**.ssh/id_dsa** are managed automatically.

a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

Example output

```
Agent pid 31874
```



NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

1 Specify the path and file name for your SSH private key, such as **~/.ssh/id_ed25519**

Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program. If you install a cluster on infrastructure that you provision, you must provide the key to the installation program.

22.8.11. Manually creating the installation configuration file

For user-provisioned installations of OpenShift Container Platform, you manually generate your installation configuration file. For user-provisioned installations of OpenShift Container Platform, you manually generate your installation configuration file.

IMPORTANT

The Cluster Cloud Controller Manager Operator performs a connectivity check on a provided hostname or IP address. Ensure that you specify a hostname or an IP address to a reachable vCenter server. If you provide metadata to a non-existent vCenter server, installation of the cluster fails at the bootstrap stage.

Prerequisites

- You have an SSH public key on your local machine to provide to the installation program. The key will be used for SSH authentication onto your cluster nodes for debugging and disaster recovery.
- You have obtained the OpenShift Container Platform installation program and the pull secret for your cluster.
- Obtain the **imageContentSources** section from the output of the command to mirror the repository.
- Obtain the contents of the certificate for your mirror registry.

Procedure

1. Create an installation directory to store your required installation assets in:

```
$ mkdir <installation_directory>
```

IMPORTANT

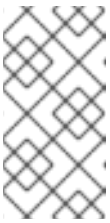
You must create a directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

2. Customize the sample **install-config.yaml** file template that is provided and save it in the **<installation_directory>**.

NOTE

You must name this configuration file **install-config.yaml**.

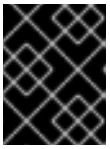
- Unless you use a registry that RHCOS trusts by default, such as **docker.io**, you must provide the contents of the certificate for your mirror repository in the **additionalTrustBundle** section. In most cases, you must provide the certificate for your mirror.
- You must include the **imageContentSources** section from the output of the command to mirror the repository.



NOTE

For some platform types, you can alternatively run **./openshift-install create install-config --dir <installation_directory>** to generate an **install-config.yaml** file. You can provide details about your cluster configuration at the prompts.

3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.



IMPORTANT

The **install-config.yaml** file is consumed during the next step of the installation process. You must back it up now.

22.8.11.1. Sample install-config.yaml file for VMware vSphere

You can customize the **install-config.yaml** file to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.

```
apiVersion: v1
baseDomain: example.com (1)
compute: (2)
  name: worker
  replicas: 0 (3)
controlPlane: (4)
  name: master
  replicas: 3 (5)
metadata:
```

```
  name: test 6
platform:
  vsphere:
    vcenter: your.vcenter.server 7
    username: username 8
    password: password 9
    datacenter: datacenter 10
    defaultDatastore: datastore 11
    folder: "/<datacenter_name>/vm/<folder_name>/<subfolder_name>" 12
    resourcePool: "/<datacenter_name>/host/<cluster_name>/Resources/<resource_pool_name>" 13
    diskType: thin 14
fips: false 15
pullSecret: '{"auths":{"<local_registry>": {"auth": "<credentials>","email": "you@example.com"}}}' 16
sshKey: 'ssh-ed25519 AAAA...' 17
additionalTrustBundle: | 18
  -----BEGIN CERTIFICATE-----
  ZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZ
  -----END CERTIFICATE-----
imageContentSources: 19
- mirrors:
  - <mirror_host_name>:<mirror_port>/<repo_name>/release
  source: <source_image_1>
- mirrors:
  - <mirror_host_name>:<mirror_port>/<repo_name>/release-images
  source: <source_image_2>
```

1 The base domain of the cluster. All DNS records must be sub-domains of this base and include the cluster name.

2 4 The **controlPlane** section is a single mapping, but the compute section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, (**-**), and the first line of the **controlPlane** section must not. Although both sections currently define a single machine pool, it is possible that future versions of OpenShift Container Platform will support defining multiple compute pools during installation. Only one control plane pool is used.

3 You must set the value of the **replicas** parameter to **0**. This parameter controls the number of workers that the cluster creates and manages for you, which are functions that the cluster does not perform when you use user-provisioned infrastructure. You must manually deploy worker machines for the cluster to use before you finish installing OpenShift Container Platform.

5 The number of control plane machines that you add to the cluster. Because the cluster uses this values as the number of etcd endpoints in the cluster, the value must match the number of control plane machines that you deploy.

6 The cluster name that you specified in your DNS records.

7 The fully-qualified hostname or IP address of the vCenter server.

IMPORTANT

The Cluster Cloud Controller Manager Operator performs a connectivity check on a provided hostname or IP address. Ensure that you specify a hostname or an IP address to a reachable vCenter server. If you provide metadata to a non-existent vCenter server, installation of the cluster fails at the bootstrap stage.

8. The name of the user for accessing the server.
9. The password associated with the vSphere user.
10. The vSphere datacenter.
11. The default vSphere datastore to use.
12. Optional parameter: For installer-provisioned infrastructure, the absolute path of an existing folder where the installation program creates the virtual machines, for example, **/<datacenter_name>/vm/<folder_name>/<subfolder_name>**. If you do not provide this value, the installation program creates a top-level folder in the datacenter virtual machine folder that is named with the infrastructure ID. If you are providing the infrastructure for the cluster and you do not want to use the default **StorageClass** object, named **thin**, you can omit the **folder** parameter from the **install-config.yaml** file.
13. Optional parameter: For installer-provisioned infrastructure, the absolute path of an existing folder where the installation program creates the virtual machines, for example, **/<datacenter_name>/vm/<folder_name>/<subfolder_name>**. If you do not provide this value, the installation program creates a top-level folder in the datacenter virtual machine folder that is named with the infrastructure ID. If you are providing the infrastructure for the cluster, omit this parameter.
14. The vSphere disk provisioning method.
15. Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.

IMPORTANT

To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.

16. For **<local_registry>**, specify the registry domain name, and optionally the port, that your mirror registry uses to serve content. For example **registry.example.com** or **registry.example.com:5000**. For **<credentials>**, specify the base64-encoded user name and password for your mirror registry.
17. The public portion of the default SSH key for the **core** user in Red Hat Enterprise Linux CoreOS (RHCOS).

NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

18 Provide the contents of the certificate file that you used for your mirror registry.

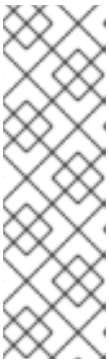
19 Provide the **imageContentSources** section from the output of the command to mirror the repository.

22.8.11.2. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.



NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
```

1. A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
2. A proxy URL to use for creating HTTPS connections outside the cluster.
3. A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use ***** to bypass the proxy for all destinations. You must include vCenter's IP address and the IP range that you use for its machines.
4. If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace that contains one or more additional CA certificates that are required for proxying HTTPS connections. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges these contents with the Red Hat Enterprise Linux CoreOS (RHCOS) trust bundle, and this config map is referenced in the **trustedCA** field of the **Proxy** object. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.

NOTE

The installation program does not support the proxy **readinessEndpoints** field.

NOTE

If the installer times out, restart and then complete the deployment by using the **wait-for** command of the installer. For example:

```
$ ./openshift-install wait-for install-complete --log-level debug
```

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.

NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

22.8.12. Creating the Kubernetes manifest and Ignition config files

Because you must modify some cluster definition files and manually start the cluster machines, you must generate the Kubernetes manifest and Ignition config files that the cluster needs to configure the machines.

The installation configuration file transforms into the Kubernetes manifests. The manifests wrap into the Ignition configuration files, which are later used to configure the cluster machines.

IMPORTANT

- The Ignition config files that the OpenShift Container Platform installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

Prerequisites

- You obtained the OpenShift Container Platform installation program. For a restricted network installation, these files are on your mirror host.
- You created the **install-config.yaml** installation configuration file.

Procedure

1. Change to the directory that contains the OpenShift Container Platform installation program and generate the Kubernetes manifests for the cluster:

```
$ ./openshift-install create manifests --dir <installation_directory> 1
```

1 For **<installation_directory>**, specify the installation directory that contains the **install-config.yaml** file you created.

2. Remove the Kubernetes manifest files that define the control plane machines and compute machine sets:

```
$ rm -f openshift/99_openshift-cluster-api_master-machines-*.yaml openshift/99_openshift-cluster-api_worker-machineset-*.yaml
```

Because you create and manage these resources yourself, you do not have to initialize them.

- You can preserve the machine set files to create compute machines by using the machine API, but you must update references to them to match your environment.

3. Check that the **mastersSchedulable** parameter in the **<installation_directory>/manifests/cluster-scheduler-02-config.yml** Kubernetes manifest file is set to **false**. This setting prevents pods from being scheduled on the control plane machines:

   a. Open the **<installation_directory>/manifests/cluster-scheduler-02-config.yml** file.

   b. Locate the **mastersSchedulable** parameter and ensure that it is set to **false**.

   c. Save and exit the file.

4. To create the Ignition configuration files, run the following command from the directory that contains the installation program:

```
$ ./openshift-install create ignition-configs --dir <installation_directory> 1
```

1 For **<installation_directory>**, specify the same installation directory.

Ignition config files are created for the bootstrap, control plane, and compute nodes in the installation directory. The **kubeadmin-password** and **kubeconfig** files are created in the **./<installation_directory>/auth** directory:

```
.
├── auth
│   ├── kubeadmin-password
│   └── kubeconfig
├── bootstrap.ign
├── master.ign
├── metadata.json
└── worker.ign
```

22.8.13. Extracting the infrastructure name

The Ignition config files contain a unique cluster identifier that you can use to uniquely identify your cluster in VMware Cloud on AWS. If you plan to use the cluster identifier as the name of your virtual machine folder, you must extract it.

Prerequisites

- You obtained the OpenShift Container Platform installation program and the pull secret for your cluster.
- You generated the Ignition config files for your cluster.
- You installed the **jq** package.

Procedure

- To extract and view the infrastructure name from the Ignition config file metadata, run the following command:

```
$ jq -r .infraID <installation_directory>/metadata.json 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

Example output

```
openshift-vw9j6 1
```

1 The output of this command is your cluster name and a random string.

22.8.14. Installing RHCOS and starting the OpenShift Container Platform bootstrap process

To install OpenShift Container Platform on user-provisioned infrastructure on VMware vSphere, you must install Red Hat Enterprise Linux CoreOS (RHCOS) on vSphere hosts. When you install RHCOS, you must provide the Ignition config file that was generated by the OpenShift Container Platform installation program for the type of machine you are installing. If you have configured suitable networking, DNS, and load balancing infrastructure, the OpenShift Container Platform bootstrap process begins automatically after the RHCOS machines have rebooted.

Prerequisites

- You have obtained the Ignition config files for your cluster.
- You have access to an HTTP server that you can access from your computer and that the machines that you create can access.
- You have created a vSphere cluster.

Procedure

1. Upload the bootstrap Ignition config file, which is named **<installation_directory>/bootstrap.ign**, that the installation program created to your HTTP server. Note the URL of this file.
2. Save the following secondary Ignition config file for your bootstrap node to your computer as **<installation_directory>/merge-bootstrap.ign**:

```
{
  "ignition": {
    "config": {
      "merge": [
        {
          "source": "<bootstrap_ignition_config_url>", 1
          "verification": {}
        }
      ]
    },
    "timeouts": {},
    "version": "3.2.0"
  },
  "networkd": {},
  "passwd": {},
  "storage": {},
  "systemd": {}
}
```

1 Specify the URL of the bootstrap Ignition config file that you hosted.

When you create the virtual machine (VM) for the bootstrap machine, you use this Ignition config file.

3. Locate the following Ignition config files that the installation program created:
   - **<installation_directory>/master.ign**

- **<installation_directory>/worker.ign**
- **<installation_directory>/merge-bootstrap.ign**

4. Convert the Ignition config files to Base64 encoding. Later in this procedure, you must add these files to the extra configuration parameter **guestinfo.ignition.config.data** in your VM. For example, if you use a Linux operating system, you can use the **base64** command to encode the files.

```
$ base64 -w0 <installation_directory>/master.ign > <installation_directory>/master.64
```

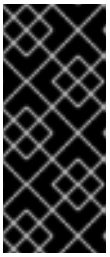
```
$ base64 -w0 <installation_directory>/worker.ign > <installation_directory>/worker.64
```

```
$ base64 -w0 <installation_directory>/merge-bootstrap.ign > <installation_directory>/merge-bootstrap.64
```

IMPORTANT

If you plan to add more compute machines to your cluster after you finish installation, do not delete these files.

5. Obtain the RHCOS OVA image. Images are available from the RHCOS image mirror page.



IMPORTANT

The RHCOS images might not change with every release of OpenShift Container Platform. You must download an image with the highest version that is less than or equal to the OpenShift Container Platform version that you install. Use the image version that matches your OpenShift Container Platform version if it is available.

The filename contains the OpenShift Container Platform version number in the format **rhcos-vmware.<architecture>.ova**.

6. In the vSphere Client, create a folder in your datacenter to store your VMs.
   a. Click the **VMs and Templates** view.
   b. Right-click the name of your datacenter.
   c. Click **New Folder → New VM and Template Folder**.
   d. In the window that is displayed, enter the folder name. If you did not specify an existing folder in the **install-config.yaml** file, then create a folder with the same name as the infrastructure ID. You use this folder name so vCenter dynamically provisions storage in the appropriate location for its Workspace configuration.
7. In the vSphere Client, create a template for the OVA image and then clone the template as needed.

NOTE

In the following steps, you create a template and then clone the template for all of your cluster machines. You then provide the location for the Ignition config file for that cloned machine type when you provision the VMs.

a. From the **Hosts and Clusters** tab, right-click your cluster name and select **Deploy OVF Template**.

b. On the **Select an OVF** tab, specify the name of the RHCOS OVA file that you downloaded.

c. On the **Select a name and folder** tab, set a **Virtual machine name** for your template, such as **Template-RHCOS**. Click the name of your vSphere cluster and select the folder you created in the previous step.

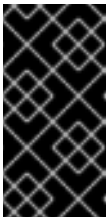
d. On the **Select a compute resource** tab, click the name of your vSphere cluster.

e. On the **Select storage** tab, configure the storage options for your VM.

- Select **Thin Provision** or **Thick Provision**, based on your storage preferences.
- Select the datastore that you specified in your **install-config.yaml** file.

f. On the **Select network** tab, specify the network that you configured for the cluster, if available.

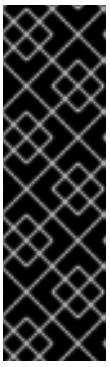
g. When creating the OVF template, do not specify values on the **Customize template** tab or configure the template any further.



IMPORTANT

Do not start the original VM template. The VM template must remain off and must be cloned for new RHCOS machines. Starting the VM template configures the VM template as a VM on the platform, which prevents it from being used as a template that machine sets can apply configurations to.

8. Optional: Update the configured virtual hardware version in the VM template, if necessary. Follow Upgrading a virtual machine to the latest hardware version in the VMware documentation for more information.



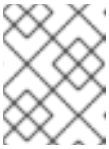
IMPORTANT

It is recommended that you update the hardware version of the VM template to version 15 before creating VMs from it, if necessary. Using hardware version 13 for your cluster nodes running on vSphere is now deprecated. If your imported template defaults to hardware version 13, you must ensure that your ESXi host is on 6.7U3 or later before upgrading the VM template to hardware version 15. If your vSphere version is less than 6.7U3, you can skip this upgrade step; however, a future version of OpenShift Container Platform is scheduled to remove support for hardware version 13 and vSphere versions less than 6.7U3.

9. After the template deploys, deploy a VM for a machine in the cluster.

a. Right-click the template name and click **Clone → Clone to Virtual Machine**

b. On the **Select a name and folder** tab, specify a name for the VM. You might include the machine type in the name, such as **control-plane-0** or **compute-1**.



NOTE

Ensure that all virtual machine names across a vSphere installation are unique.

c. On the **Select a name and folder** tab, select the name of the folder that you created for the cluster.

d. On the **Select a compute resource** tab, select the name of a host in your datacenter.

e. On the **Select clone options**, select **Customize this virtual machine's hardware**.

f. Optional: On the **Customize hardware** tab, click **VM Options → Advanced**.

IMPORTANT

The following configuration suggestions are for example purposes only. As a cluster administrator, you must configure resources according to the resource demands placed on your cluster. To best manage cluster resources, consider creating a resource pool from the cluster's root resource pool.

- Override default DHCP networking in vSphere. To enable static IP networking:
  - Set your static IP configuration:

```
$ export IPCFG="ip=<ip>::<gateway>:<netmask>:<hostname>:<iface>:none
nameserver=srv1 [nameserver=srv2 [nameserver=srv3 [...]]]"
```

Example command

```
$ export IPCFG="ip=192.168.100.101::192.168.100.254:255.255.255.0:::none
nameserver=8.8.8.8"
```

- Click **Edit Configuration**, and on the **Configuration Parameters** window, search the list of available parameters for steal clock accounting (**stealclock.enable**). Set the parameter to the value of **TRUE**. Enabling steal clock accounting can help with troubleshooting cluster issues.
- Click **Add Configuration Params**. Define the following parameter names and values:
  - **disk.EnableUUID**: Specify **TRUE**.
  - **stealclock.enable**: If this parameter was not defined, add it and specify **TRUE**.
  - Create a child resource pool from the cluster's root resource pool. Perform resource allocation in this child resource pool.

g. In the **Virtual Hardware** panel of the **Customize hardware** tab, modify the specified values as required. Ensure that the amount of RAM, CPU, and disk storage meets the minimum requirements for the machine type.

h. Complete the configuration and power on the VM.

i. Check the console output to verify that Ignition ran.

Example command

```
Ignition: ran on 2022/03/14 14:48:33 UTC (this boot)
Ignition: user-provided config was applied
```

10. Create the rest of the machines for your cluster by following the preceding steps for each machine.

IMPORTANT

You must create the bootstrap and control plane machines at this time. Because some pods are deployed on compute machines by default, also create at least two compute machines before you install the cluster.

22.8.15. Adding more compute machines to a cluster in vSphere

You can add more compute machines to a user-provisioned OpenShift Container Platform cluster on VMware vSphere.

Prerequisites

- Obtain the base64-encoded Ignition file for your compute machines.
- You have access to the vSphere template that you created for your cluster.

Procedure

1. After the template deploys, deploy a VM for a machine in the cluster.
   a. Right-click the template's name and click **Clone → Clone to Virtual Machine**
   b. On the **Select a name and folder** tab, specify a name for the VM. You might include the machine type in the name, such as **compute-1**.

NOTE

Ensure that all virtual machine names across a vSphere installation are unique.

   c. On the **Select a name and folder** tab, select the name of the folder that you created for the cluster.
   d. On the **Select a compute resource** tab, select the name of a host in your datacenter.
   e. On the **Select clone options**, select **Customize this virtual machine's hardware**.
   f. On the **Customize hardware** tab, click **VM Options → Advanced**.
      - Click **Edit Configuration**, and on the **Configuration Parameters** window, click **Add Configuration Params**. Define the following parameter names and values:
        - **guestinfo.ignition.config.data**: Paste the contents of the base64-encoded compute Ignition config file for this machine type.

- **guestinfo.ignition.config.data.encoding**: Specify **base64**.
- **disk.EnableUUID**: Specify **TRUE**.

g. In the **Virtual Hardware** panel of the **Customize hardware** tab, modify the specified values as required. Ensure that the amount of RAM, CPU, and disk storage meets the minimum requirements for the machine type. Also, make sure to select the correct network under **Add network adapter** if there are multiple networks available.

h. Complete the configuration and power on the VM.

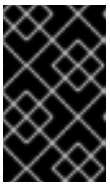
2. Continue to create more compute machines for your cluster.

22.8.16. Disk partitioning

In most cases, data partitions are originally created by installing RHCOS, rather than by installing another operating system. In such cases, the OpenShift Container Platform installer should be allowed to configure your disk partitions.

However, there are two cases where you might want to intervene to override the default partitioning when installing an OpenShift Container Platform node:

- Create separate partitions: For greenfield installations on an empty disk, you might want to add separate storage to a partition. This is officially supported for making **/var** or a subdirectory of **/var**, such as **/var/lib/etcd**, a separate partition, but not both.



IMPORTANT

For disk sizes larger than 100GB, and especially disk sizes larger than 1TB, create a separate **/var** partition. See "Creating a separate **/var** partition" and this Red Hat Knowledgebase article for more information.

IMPORTANT

Kubernetes supports only two file system partitions. If you add more than one partition to the original configuration, Kubernetes cannot monitor all of them.

- Retain existing partitions: For a brownfield installation where you are reinstalling OpenShift Container Platform on an existing node and want to retain data partitions installed from your previous operating system, there are both boot arguments and options to **coreos-installer** that allow you to retain existing data partitions.

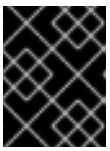
Creating a separate /var partition

In general, disk partitioning for OpenShift Container Platform should be left to the installer. However, there are cases where you might want to create separate partitions in a part of the filesystem that you expect to grow.

OpenShift Container Platform supports the addition of a single partition to attach storage to either the **/var** partition or a subdirectory of **/var**. For example:

- **/var/lib/containers**: Holds container-related content that can grow as more images and containers are added to a system.
- **/var/lib/etcd**: Holds data that you might want to keep separate for purposes such as performance optimization of etcd storage.

- /**var**: Holds data that you might want to keep separate for purposes such as auditing.



IMPORTANT

For disk sizes larger than 100GB, and especially larger than 1TB, create a separate /**var** partition.

Storing the contents of a /**var** directory separately makes it easier to grow storage for those areas as needed and reinstall OpenShift Container Platform at a later date and keep that data intact. With this method, you will not have to pull all your containers again, nor will you have to copy massive log files when you update systems.

Because /**var** must be in place before a fresh installation of Red Hat Enterprise Linux CoreOS (RHCOS), the following procedure sets up the separate /**var** partition by creating a machine config manifest that is inserted during the **openshift-install** preparation phases of an OpenShift Container Platform installation.

Procedure

1. Create a directory to hold the OpenShift Container Platform installation files:

```
$ mkdir $HOME/clusterconfig
```

2. Run **openshift-install** to create a set of files in the **manifest** and **openshift** subdirectories. Answer the system questions as you are prompted:

```
$ openshift-install create manifests --dir $HOME/clusterconfig
? SSH Public Key ...
$ ls $HOME/clusterconfig/openshift/
99_kubeadmin-password-secret.yaml
99_openshift-cluster-api_master-machines-0.yaml
99_openshift-cluster-api_master-machines-1.yaml
99_openshift-cluster-api_master-machines-2.yaml
...
```

3. Create a Butane config that configures the additional partition. For example, name the file **$HOME/clusterconfig/98-var-partition.bu**, change the disk device name to the name of the storage device on the **worker** systems, and set the storage size as appropriate. This example places the /**var** directory on a separate partition:

```
variant: openshift
version: 4.11.0
metadata:
  labels:
    machineconfiguration.openshift.io/role: worker
  name: 98-var-partition
storage:
  disks:
  - device: /dev/<device_name> 1
    partitions:
    - label: var
      start_mib: <partition_start_offset> 2
      size_mib: <partition_size> 3
  filesystems:
```

```
 - device: /dev/disk/by-partlabel/var
   path: /var
   format: xfs
   mount_options: [defaults, prjquota] 4
   with_mount_unit: true
```

1. The storage device name of the disk that you want to partition.
2. When adding a data partition to the boot disk, a minimum value of 25000 mebibytes is recommended. The root file system is automatically resized to fill all available space up to the specified offset. If no value is specified, or if the specified value is smaller than the recommended minimum, the resulting root file system will be too small, and future reinstalls of RHCOS might overwrite the beginning of the data partition.
3. The size of the data partition in mebibytes.
4. The **prjquota** mount option must be enabled for filesystems used for container storage.

NOTE

When creating a separate **/var** partition, you cannot use different instance types for worker nodes, if the different instance types do not have the same device name.

4. Create a manifest from the Butane config and save it to the **clusterconfig/openshift** directory. For example, run the following command:

```
$ butane $HOME/clusterconfig/98-var-partition.bu -o $HOME/clusterconfig/openshift/98-var-partition.yaml
```

5. Run **openshift-install** again to create Ignition configs from a set of files in the **manifest** and **openshift** subdirectories:

```
$ openshift-install create ignition-configs --dir $HOME/clusterconfig
$ ls $HOME/clusterconfig/
auth  bootstrap.ign  master.ign  metadata.json  worker.ign
```

Now you can use the Ignition config files as input to the vSphere installation procedures to install Red Hat Enterprise Linux CoreOS (RHCOS) systems.

22.8.17. Updating the bootloader using bootupd

To update the bootloader by using **bootupd**, you must either install **bootupd** on RHCOS machines manually or provide a machine config with the enabled **systemd** unit. Unlike **grubby** or other bootloader tools, **bootupd** does not manage kernel space configuration such as passing kernel arguments.

After you have installed **bootupd**, you can manage it remotely from the OpenShift Container Platform cluster.

NOTE

It is recommended that you use **bootupd** only on bare metal or virtualized hypervisor installations, such as for protection against the BootHole vulnerability.

Manual install method

You can manually install **bootupd** by using the **bootctl** command-line tool.

1. Inspect the system status:

```
# bootupctl status
```

Example output for x86_64

```
Component EFI
  Installed: grub2-efi-x64-1:2.04-31.fc33.x86_64,shim-x64-15-8.x86_64
  Update: At latest version
```

Example output for aarch64

```
Component EFI
  Installed: grub2-efi-aa64-1:2.02-99.el8_4.1.aarch64,shim-aa64-15.4-2.el8_1.aarch64
  Update: At latest version
```

2. RHCOS images created without **bootupd** installed on them require an explicit adoption phase. If the system status is **Adoptable**, perform the adoption:

```
# bootupctl adopt-and-update
```

Example output

```
Updated: grub2-efi-x64-1:2.04-31.fc33.x86_64,shim-x64-15-8.x86_64
```

3. If an update is available, apply the update so that the changes take effect on the next reboot:

```
# bootupctl update
```

Example output

```
Updated: grub2-efi-x64-1:2.04-31.fc33.x86_64,shim-x64-15-8.x86_64
```

Machine config method

Another way to enable **bootupd** is by providing a machine config.

- Provide a machine config file with the enabled **systemd** unit, as shown in the following example:

Example output

```
variant: rhcos
version: 1.1.0
```

```
systemd:
  units:
    - name: custom-bootupd-auto.service
      enabled: true
      contents: |
        [Unit]
        Description=Bootupd automatic update

        [Service]
        ExecStart=/usr/bin/bootupctl update
        RemainAfterExit=yes

        [Install]
        WantedBy=multi-user.target
```

22.8.18. Waiting for the bootstrap process to complete

The OpenShift Container Platform bootstrap process begins after the cluster nodes first boot into the persistent RHCOS environment that has been installed to disk. The configuration information provided through the Ignition config files is used to initialize the bootstrap process and install OpenShift Container Platform on the machines. You must wait for the bootstrap process to complete.

Prerequisites

- You have created the Ignition config files for your cluster.
- You have configured suitable network, DNS and load balancing infrastructure.
- You have obtained the installation program and generated the Ignition config files for your cluster.
- You installed RHCOS on your cluster machines and provided the Ignition config files that the OpenShift Container Platform installation program generated.

Procedure

1. Monitor the bootstrap process:

```
$ ./openshift-install --dir <installation_directory> wait-for bootstrap-complete \ 1
    --log-level=info 2
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

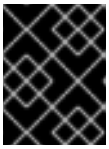
2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

Example output

```
INFO Waiting up to 30m0s for the Kubernetes API at https://api.test.example.com:6443...
INFO API v1.24.0 up
INFO Waiting up to 30m0s for bootstrapping to complete...
INFO It is now safe to remove the bootstrap resources
```

The command succeeds when the Kubernetes API server signals that it has been bootstrapped on the control plane machines.

2. After the bootstrap process is complete, remove the bootstrap machine from the load balancer.



IMPORTANT

You must remove the bootstrap machine from the load balancer at this point. You can also remove or reformat the bootstrap machine itself.

22.8.19. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

Example output

```
system:admin
```

22.8.20. Approving the certificate signing requests for your machines

When you add machines to a cluster, two pending certificate signing requests (CSRs) are generated for each machine that you added. You must confirm that these CSRs are approved or, if necessary, approve them yourself. The client requests must be approved first, followed by the server requests.

Prerequisites

- You added machines to your cluster.

Procedure

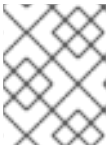
1. Confirm that the cluster recognizes the machines:

```
$ oc get nodes
```

Example output

```
NAME      STATUS    ROLES   AGE  VERSION
master-0  Ready     master  63m  v1.24.0
master-1  Ready     master  63m  v1.24.0
master-2  Ready     master  64m  v1.24.0
```

The output lists all of the machines that you created.



NOTE

The preceding output might not include the compute nodes, also known as worker nodes, until some CSRs are approved.

2. Review the pending CSRs and ensure that you see the client requests with the **Pending** or **Approved** status for each machine that you added to the cluster:

```
$ oc get csr
```

Example output

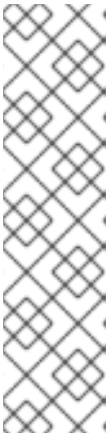
```
NAME        AGE    REQUESTOR                                                    CONDITION
csr-8b2br   15m    system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper   Pending
csr-8vnps   15m    system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper   Pending
...
```

In this example, two machines are joining the cluster. You might see more approved CSRs in the list.

3. If the CSRs were not approved, after all of the pending CSRs for the machines you added are in **Pending** status, approve the CSRs for your cluster machines:

NOTE

Because the CSRs rotate automatically, approve your CSRs within an hour of adding the machines to the cluster. If you do not approve them within an hour, the certificates will rotate, and more than two certificates will be present for each node. You must approve all of these certificates. After the client CSR is approved, the Kubelet creates a secondary CSR for the serving certificate, which requires manual approval. Then, subsequent serving certificate renewal requests are automatically approved by the **machine-approver** if the Kubelet requests a new certificate with identical parameters.



NOTE

For clusters running on platforms that are not machine API enabled, such as bare metal and other user-provisioned infrastructure, you must implement a method of automatically approving the kubelet serving certificate requests (CSRs). If a request is not approved, then the **oc exec**, **oc rsh**, and **oc logs** commands cannot succeed, because a serving certificate is required when the API server connects to the kubelet. Any operation that contacts the Kubelet endpoint requires this certificate approval to be in place. The method must watch for new CSRs, confirm that the CSR was submitted by the **node-bootstrapper** service account in the **system:node** or **system:admin** groups, and confirm the identity of the node.

- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

1 **<csr_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{{"\n"}}
{{end}}{{end}}' | xargs --no-run-if-empty oc adm certificate approve
```

NOTE

Some Operators might not become available until some CSRs are approved.

4. Now that your client requests are approved, you must review the server requests for each machine that you added to the cluster:

```
$ oc get csr
```

Example output

```
NAME        AGE    REQUESTOR                                                   CONDITION
csr-bfd72   5m26s  system:node:ip-10-0-50-126.us-east-2.compute.internal
Pending
csr-c57lv   5m26s  system:node:ip-10-0-95-157.us-east-2.compute.internal
Pending
...
```

5. If the remaining CSRs are not approved, and are in the **Pending** status, approve the CSRs for your cluster machines:

- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

1 **<csr_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

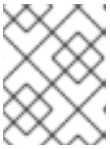
```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{{"\n"}}
{{end}}{{end}}' | xargs oc adm certificate approve
```

6. After all client and server CSRs have been approved, the machines have the **Ready** status. Verify this by running the following command:

```
$ oc get nodes
```

Example output

```
NAME      STATUS    ROLES   AGE  VERSION
master-0  Ready     master  73m  v1.24.0
master-1  Ready     master  73m  v1.24.0
master-2  Ready     master  74m  v1.24.0
worker-0  Ready     worker  11m  v1.24.0
worker-1  Ready     worker  11m  v1.24.0
```



NOTE

It can take a few minutes after approval of the server CSRs for the machines to transition to the **Ready** status.

Additional information

- For more information on CSRs, see Certificate Signing Requests.

22.8.21. Initial Operator configuration

After the control plane initializes, you must immediately configure some Operators so that they all become available.

Prerequisites

- Your control plane has initialized.

Procedure

1. Watch the cluster components come online:

```
$ watch -n5 oc get clusteroperators
```

Example output

```
NAME                                       VERSION   AVAILABLE   PROGRESSING   DEGRADED
SINCE
authentication                              4.11.0    True        False         False      19m
baremetal                                  4.11.0    True        False         False      37m
cloud-credential                            4.11.0    True        False         False      40m
cluster-autoscaler                          4.11.0    True        False         False      37m
config-operator                             4.11.0    True        False         False      38m
```

```
console                                    4.11.0    True        False        False      26m
csi-snapshot-controller                    4.11.0    True        False        False      37m
dns                                        4.11.0    True        False        False      37m
etcd                                       4.11.0    True        False        False      36m
image-registry                             4.11.0    True        False        False      31m
ingress                                    4.11.0    True        False        False      30m
insights                                   4.11.0    True        False        False      31m
kube-apiserver                             4.11.0    True        False        False      26m
kube-controller-manager                    4.11.0    True        False        False      36m
kube-scheduler                             4.11.0    True        False        False      36m
kube-storage-version-migrator              4.11.0    True        False        False      37m
machine-api                                4.11.0    True        False        False      29m
machine-approver                           4.11.0    True        False        False      37m
machine-config                             4.11.0    True        False        False      36m
marketplace                                4.11.0    True        False        False      37m
monitoring                                 4.11.0    True        False        False      29m
network                                    4.11.0    True        False        False      38m
node-tuning                                4.11.0    True        False        False      37m
openshift-apiserver                        4.11.0    True        False        False      32m
openshift-controller-manager               4.11.0    True        False        False      30m
openshift-samples                          4.11.0    True        False        False      32m
operator-lifecycle-manager                 4.11.0    True        False        False      37m
operator-lifecycle-manager-catalog         4.11.0    True        False        False      37m
operator-lifecycle-manager-packageserver   4.11.0    True        False        False      32m
service-ca                                 4.11.0    True        False        False      38m
storage                                    4.11.0    True        False        False      37m
```

2. Configure the Operators that are not available.

22.8.21.1. Disabling the default OperatorHub sources

Operator catalogs that source content provided by Red Hat and community projects are configured for OperatorHub by default during an OpenShift Container Platform installation. In a restricted network environment, you must disable the default catalogs as a cluster administrator.

Procedure

- Disable the sources for the default catalogs by adding **disableAllDefaultSources: true** to the **OperatorHub** object:

```
$ oc patch OperatorHub cluster --type json \
    -p '[{"op": "add", "path": "/spec/disableAllDefaultSources", "value": true}]'
```

TIP

Alternatively, you can use the web console to manage catalog sources. From the **Administration → Cluster Settings → Configuration → OperatorHub** page, click the **Sources** tab, where you can create, update, delete, disable, and enable individual sources.

22.8.21.2. Image registry storage configuration

The Image Registry Operator is not initially available for platforms that do not provide default storage. After installation, you must configure your registry to use storage so that the Registry Operator is made available.

Instructions are shown for configuring a persistent volume, which is required for production clusters. Where applicable, instructions are shown for configuring an empty directory as the storage location, which is available for only non-production clusters.

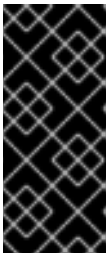
Additional instructions are provided for allowing the image registry to use block storage types by using the **Recreate** rollout strategy during upgrades.

22.8.21.2.1. Configuring registry storage for VMware vSphere

As a cluster administrator, following installation you must configure your registry to use storage.

Prerequisites

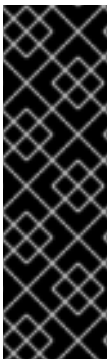
- Cluster administrator permissions.
- A cluster on VMware vSphere.
- Persistent storage provisioned for your cluster, such as Red Hat OpenShift Data Foundation.



IMPORTANT

OpenShift Container Platform supports **ReadWriteOnce** access for image registry storage when you have only one replica. **ReadWriteOnce** access also requires that the registry uses the **Recreate** rollout strategy. To deploy an image registry that supports high availability with two or more replicas, **ReadWriteMany** access is required.

- Must have "100Gi" capacity.



IMPORTANT

Testing shows issues with using the NFS server on RHEL as storage backend for core services. This includes the OpenShift Container Registry and Quay, Prometheus for monitoring storage, and Elasticsearch for logging storage. Therefore, using RHEL NFS to back PVs used by core services is not recommended.

Other NFS implementations on the marketplace might not have these issues. Contact the individual NFS implementation vendor for more information on any testing that was possibly completed against these OpenShift Container Platform core components.

Procedure

1. To configure your registry to use storage, change the **spec.storage.pvc** in the **configs.imageregistry/cluster** resource.

NOTE

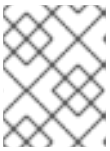
When you use shared storage, review your security settings to prevent outside access.

2. Verify that you do not have a registry pod:

```
$ oc get pod -n openshift-image-registry -l docker-registry=default
```

Example output

```
No resourses found in openshift-image-registry namespace
```



NOTE

If you do have a registry pod in your output, you do not need to continue with this procedure.

3. Check the registry configuration:

```
$ oc edit configs.imageregistry.operator.openshift.io
```

Example output

```
storage:
  pvc:
    claim: 1
```

1 Leave the **claim** field blank to allow the automatic creation of an **image-registry-storage** persistent volume claim (PVC). The PVC is generated based on the default storage class. However, be aware that the default storage class might provide ReadWriteOnce (RWO) volumes, such as a RADOS Block Device (RBD), which can cause issues when you replicate to more than one replica.

4. Check the **clusteroperator** status:

```
$ oc get clusteroperator image-registry
```

Example output

```
NAME             VERSION                             AVAILABLE   PROGRESSING   DEGRADED
SINCE   MESSAGE
image-registry   4.7                                 True        False         False      6h50m
```

22.8.21.2.2. Configuring storage for the image registry in non-production clusters

You must configure storage for the Image Registry Operator. For non-production clusters, you can set the image registry to an empty directory. If you do so, all images are lost if you restart the registry.

Procedure

- To set the image registry storage to an empty directory:

```
$ oc patch configs.imageregistry.operator.openshift.io cluster --type merge --patch '{"spec":
{"storage":{"emptyDir":{}}}}'
```

WARNING

Configure this option for only non-production clusters.

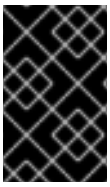
If you run this command before the Image Registry Operator initializes its components, the **oc patch** command fails with the following error:

```
Error from server (NotFound): configs.imageregistry.operator.openshift.io "cluster" not found
```

Wait a few minutes and run the command again.

22.8.21.2.3. Configuring block registry storage for VMware vSphere

To allow the image registry to use block storage types such as vSphere Virtual Machine Disk (VMDK) during upgrades as a cluster administrator, you can use the **Recreate** rollout strategy.



IMPORTANT

Block storage volumes are supported but not recommended for use with image registry on production clusters. An installation where the registry is configured on block storage is not highly available because the registry cannot have more than one replica.

Procedure

1. Enter the following command to set the image registry storage as a block storage type, patch the registry so that it uses the **Recreate** rollout strategy, and runs with only **1** replica:

```
$ oc patch config.imageregistry.operator.openshift.io/cluster --type=merge -p '{"spec":
{"rolloutStrategy":"Recreate","replicas":1}}'
```

2. Provision the PV for the block storage device, and create a PVC for that volume. The requested block volume uses the ReadWriteOnce (RWO) access mode.

   a. Create a **pvc.yaml** file with the following contents to define a VMware vSphere **PersistentVolumeClaim** object:

```
kind: PersistentVolumeClaim
apiVersion: v1
metadata:
  name: image-registry-storage 1
  namespace: openshift-image-registry 2
spec:
  accessModes:
  - ReadWriteOnce 3
  resources:
    requests:
      storage: 100Gi 4
```

1 A unique name that represents the **PersistentVolumeClaim** object.

2 The namespace for the **PersistentVolumeClaim** object, which is **openshift-image-registry**.

3 The access mode of the persistent volume claim. With **ReadWriteOnce**, the volume can be mounted with read and write permissions by a single node.

4 The size of the persistent volume claim.

b. Enter the following command to create the **PersistentVolumeClaim** object from the file:

```
$ oc create -f pvc.yaml -n openshift-image-registry
```

3. Enter the following command to edit the registry configuration so that it references the correct PVC:

```
$ oc edit config.imageregistry.operator.openshift.io -o yaml
```

Example output

```
storage:
  pvc:
    claim: 1
```

1 By creating a custom PVC, you can leave the **claim** field blank for the default automatic creation of an **image-registry-storage** PVC.

For instructions about configuring registry storage so that it references the correct PVC, see Configuring registry storage for VMware vSphere .

22.8.22. Completing installation on user-provisioned infrastructure

After you complete the Operator configuration, you can finish installing the cluster on infrastructure that you provide.

Prerequisites

- Your control plane has initialized.
- You have completed the initial Operator configuration.

Procedure

1. Confirm that all the cluster components are online with the following command:

```
$ watch -n5 oc get clusteroperators
```

Example output

```
NAME                                       VERSION   AVAILABLE   PROGRESSING   DEGRADED
SINCE
authentication                             4.11.0    True        False         False     19m
```

```
baremetal                                  4.11.0    True        False        False      37m
cloud-credential                           4.11.0    True        False        False      40m
cluster-autoscaler                         4.11.0    True        False        False      37m
config-operator                            4.11.0    True        False        False      38m
console                                    4.11.0    True        False        False      26m
csi-snapshot-controller                    4.11.0    True        False        False      37m
dns                                        4.11.0    True        False        False      37m
etcd                                       4.11.0    True        False        False      36m
image-registry                             4.11.0    True        False        False      31m
ingress                                    4.11.0    True        False        False      30m
insights                                   4.11.0    True        False        False      31m
kube-apiserver                             4.11.0    True        False        False      26m
kube-controller-manager                    4.11.0    True        False        False      36m
kube-scheduler                             4.11.0    True        False        False      36m
kube-storage-version-migrator              4.11.0    True        False        False      37m
machine-api                                4.11.0    True        False        False      29m
machine-approver                           4.11.0    True        False        False      37m
machine-config                             4.11.0    True        False        False      36m
marketplace                                4.11.0    True        False        False      37m
monitoring                                 4.11.0    True        False        False      29m
network                                    4.11.0    True        False        False      38m
node-tuning                                4.11.0    True        False        False      37m
openshift-apiserver                        4.11.0    True        False        False      32m
openshift-controller-manager               4.11.0    True        False        False      30m
openshift-samples                          4.11.0    True        False        False      32m
operator-lifecycle-manager                 4.11.0    True        False        False      37m
operator-lifecycle-manager-catalog         4.11.0    True        False        False      37m
operator-lifecycle-manager-packageserver   4.11.0    True        False        False      32m
service-ca                                 4.11.0    True        False        False      38m
storage                                    4.11.0    True        False        False      37m
```

Alternatively, the following command notifies you when all of the clusters are available. It also retrieves and displays credentials:

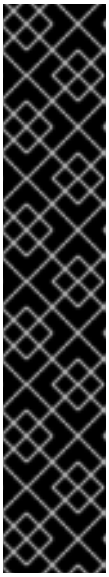
```
$ ./openshift-install --dir <installation_directory> wait-for install-complete 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

Example output

```
INFO Waiting up to 30m0s for the cluster to initialize...
```

The command succeeds when the Cluster Version Operator finishes deploying the OpenShift Container Platform cluster from Kubernetes API server.



IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

2. Confirm that the Kubernetes API server is communicating with the pods.

   a. To view a list of all pods, use the following command:

   ```
   $ oc get pods --all-namespaces
   ```

   Example output

   ```
   NAMESPACE                       NAME                                        READY   STATUS
   RESTARTS   AGE
   openshift-apiserver-operator    openshift-apiserver-operator-85cb746d55-zqhs8   1/1
   Running    1          9m
   openshift-apiserver             apiserver-67b9g                               1/1     Running     0
   3m
   openshift-apiserver             apiserver-ljcmx                               1/1     Running     0
   1m
   openshift-apiserver             apiserver-z25h4                               1/1     Running     0
   2m
   openshift-authentication-operator authentication-operator-69d5d8bf84-vh2n8        1/1
   Running    0          5m
   ...
   ```

   b. View the logs for a pod that is listed in the output of the previous command by using the following command:

   ```
   $ oc logs <pod_name> -n <namespace> 1
   ```

   1 Specify the pod name and namespace, as shown in the output of the previous command.

   If the pod logs display, the Kubernetes API server can communicate with the cluster machines.

3. For an installation with Fibre Channel Protocol (FCP), additional steps are required to enable multipathing. Do not enable multipathing during installation.
   See "Enabling multipathing with kernel arguments on RHCOS" in the *Post-installation machine configuration tasks* documentation for more information.

4. Register your cluster on the Cluster registration page.

You can add extra compute machines after the cluster installation is completed by following Adding compute machines to vSphere.

22.8.23. Backing up VMware vSphere volumes

OpenShift Container Platform provisions new volumes as independent persistent disks to freely attach and detach the volume on any node in the cluster. As a consequence, it is not possible to back up volumes that use snapshots, or to restore volumes from snapshots. See Snapshot Limitations for more information.

Procedure

To create a backup of persistent volumes:

1. Stop the application that is using the persistent volume.
2. Clone the persistent volume.
3. Restart the application.
4. Create a backup of the cloned volume.
5. Delete the cloned volume.

22.8.24. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.11, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to OpenShift Cluster Manager Hybrid Cloud Console.

After you confirm that your OpenShift Cluster Manager Hybrid Cloud Console inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, use subscription watch to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

Additional resources

- See About remote health monitoring for more information about the Telemetry service

22.8.25. Next steps

- Customize your cluster.
- Configure image streams for the Cluster Samples Operator and the **must-gather** tool.
- Learn how to use Operator Lifecycle Manager (OLM) on restricted networks .
- If the mirror registry that you used to install your cluster has a trusted CA, add it to the cluster by configuring additional trust stores.
- If necessary, you can opt out of remote health reporting .

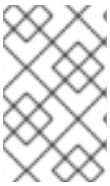
- Optional: View the events from the vSphere Problem Detector Operator to determine if the cluster has permission or storage configuration issues.

22.9. UNINSTALLING A CLUSTER ON VMC

You can remove a cluster installed on VMware vSphere infrastructure that you deployed to VMware Cloud (VMC) on AWS by using installer-provisioned infrastructure.

22.9.1. Removing a cluster that uses installer-provisioned infrastructure

You can remove a cluster that uses installer-provisioned infrastructure from your cloud.



NOTE

After uninstallation, check your cloud provider for any resources not removed properly, especially with User Provisioned Infrastructure (UPI) clusters. There might be resources that the installer did not create or that the installer is unable to access.

Prerequisites

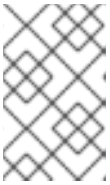
- You have a copy of the installation program that you used to deploy the cluster.
- You have the files that the installation program generated when you created your cluster.

Procedure

1. On the computer that you used to install the cluster, go to the directory that contains the installation program, and run the following command:

```
$ ./openshift-install destroy cluster \
--dir <installation_directory> --log-level info 1 2
```

1. For **<installation_directory>**, specify the path to the directory that you stored the installation files in.
2. To view different details, specify **warn**, **debug**, or **error** instead of **info**.



NOTE

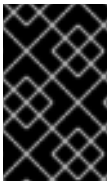
You must specify the directory that contains the cluster definition files for your cluster. The installation program requires the **metadata.json** file in this directory to delete the cluster.

2. Optional: Delete the **<installation_directory>** directory and the OpenShift Container Platform installation program.

CHAPTER 23. INSTALLING ON ANY PLATFORM

23.1. INSTALLING A CLUSTER ON ANY PLATFORM

In OpenShift Container Platform version 4.11, you can install a cluster on any infrastructure that you provision, including virtualization and cloud environments.



IMPORTANT

Review the information in the guidelines for deploying OpenShift Container Platform on non-tested platforms before you attempt to install an OpenShift Container Platform cluster in virtualized or cloud environments.

23.1.1. Prerequisites

- You reviewed details about the OpenShift Container Platform installation and update processes.
- You read the documentation on selecting a cluster installation method and preparing it for users.
- If you use a firewall, you configured it to allow the sites that your cluster requires access to.

NOTE

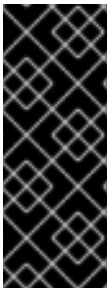
Be sure to also review this site list if you are configuring a proxy.

23.1.2. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.11, you require access to the internet to install your cluster.

You must have internet access to:

- Access OpenShift Cluster Manager Hybrid Cloud Console to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access Quay.io to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.



IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

23.1.3. Requirements for a cluster with user-provisioned infrastructure

For a cluster that contains user-provisioned infrastructure, you must deploy all of the required machines.

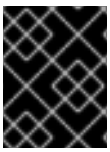
This section describes the requirements for deploying OpenShift Container Platform on user-provisioned infrastructure.

23.1.3.1. Required machines for cluster installation

The smallest OpenShift Container Platform clusters require the following hosts:

Table 23.1. Minimum required hosts

Hosts	Description
One temporary bootstrap machine	The cluster requires the bootstrap machine to deploy the OpenShift Container Platform cluster on the three control plane machines. You can remove the bootstrap machine after you install the cluster.
Three control plane machines	The control plane machines run the Kubernetes and OpenShift Container Platform services that form the control plane.
At least two compute machines, which are also known as worker machines.	The workloads requested by OpenShift Container Platform users run on the compute machines.



IMPORTANT

To maintain high availability of your cluster, use separate physical hosts for these cluster machines.

The bootstrap and control plane machines must use Red Hat Enterprise Linux CoreOS (RHCOS) as the operating system. However, the compute machines can choose between Red Hat Enterprise Linux CoreOS (RHCOS), Red Hat Enterprise Linux (RHEL) 8.6 and later.

Note that RHCOS is based on Red Hat Enterprise Linux (RHEL) 8 and inherits all of its hardware certifications and requirements. See Red Hat Enterprise Linux technology capabilities and limits .

23.1.3.2. Minimum resource requirements for cluster installation

Each cluster machine must meet the following minimum requirements:

Table 23.2. Minimum resource requirements

Machine	Operating System	vCPU [1]	Virtual RAM	Storage	IOPS [2]
Bootstrap	RHCOS	4	16 GB	100 GB	300
Control plane	RHCOS	4	16 GB	100 GB	300
Compute	RHCOS, RHEL 8.6 and later [3]	2	8 GB	100 GB	300

1. One vCPU is equivalent to one physical core when simultaneous multithreading (SMT), or hyperthreading, is not enabled. When enabled, use the following formula to calculate the corresponding ratio: (threads per core × cores) × sockets = vCPUs.

2. OpenShift Container Platform and Kubernetes are sensitive to disk performance, and faster storage is recommended, particularly for etcd on the control plane nodes which require a 10 ms p99 fsync duration. Note that on many cloud platforms, storage size and IOPS scale together, so you might need to over-allocate storage volume to obtain sufficient performance.

3. As with all user-provisioned installations, if you choose to use RHEL compute machines in your cluster, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks. Use of RHEL 7 compute machines is deprecated and has been removed in OpenShift Container Platform 4.10 and later.

If an instance type for your platform meets the minimum requirements for cluster machines, it is supported to use in OpenShift Container Platform.

23.1.3.3. Certificate signing requests management

Because your cluster has limited access to automatic machine management when you use infrastructure that you provision, you must provide a mechanism for approving cluster certificate signing requests (CSRs) after installation. The **kube-controller-manager** only approves the kubelet client CSRs. The **machine-approver** cannot guarantee the validity of a serving certificate that is requested by using kubelet credentials because it cannot confirm that the correct machine issued the request. You must determine and implement a method of verifying the validity of the kubelet serving certificate requests and approving them.

23.1.3.4. Networking requirements for user-provisioned infrastructure

All the Red Hat Enterprise Linux CoreOS (RHCOS) machines require networking to be configured in **initramfs** during boot to fetch their Ignition config files.

During the initial boot, the machines require an IP address configuration that is set either through a DHCP server or statically by providing the required boot options. After a network connection is established, the machines download their Ignition config files from an HTTP or HTTPS server. The Ignition config files are then used to set the exact state of each machine. The Machine Config Operator completes more changes to the machines, such as the application of new certificates or keys, after installation.

It is recommended to use a DHCP server for long-term management of the cluster machines. Ensure that the DHCP server is configured to provide persistent IP addresses, DNS server information, and hostnames to the cluster machines.

NOTE

If a DHCP service is not available for your user-provisioned infrastructure, you can instead provide the IP networking configuration and the address of the DNS server to the nodes at RHCOS install time. These can be passed as boot arguments if you are installing from an ISO image. See the *Installing RHCOS and starting the OpenShift Container Platform bootstrap process* section for more information about static IP provisioning and advanced networking options.

The Kubernetes API server must be able to resolve the node names of the cluster machines. If the API servers and worker nodes are in different zones, you can configure a default DNS search zone to allow

the API server to resolve the node names. Another supported approach is to always refer to hosts by their fully-qualified domain names in both the node objects and all DNS requests.

23.1.3.4.1. Setting the cluster node hostnames through DHCP

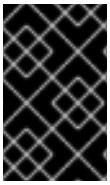
On Red Hat Enterprise Linux CoreOS (RHCOS) machines, the hostname is set through NetworkManager. By default, the machines obtain their hostname through DHCP. If the hostname is not provided by DHCP, set statically through kernel arguments, or another method, it is obtained through a reverse DNS lookup. Reverse DNS lookup occurs after the network has been initialized on a node and can take time to resolve. Other system services can start prior to this and detect the hostname as **localhost** or similar. You can avoid this by using DHCP to provide the hostname for each cluster node.

Additionally, setting the hostnames through DHCP can bypass any manual DNS record name configuration errors in environments that have a DNS split-horizon implementation.

23.1.3.4.2. Network connectivity requirements

You must configure the network connectivity between machines to allow OpenShift Container Platform cluster components to communicate. Each machine must be able to resolve the hostnames of all other machines in the cluster.

This section provides details about the ports that are required.



IMPORTANT

In connected OpenShift Container Platform environments, all nodes are required to have internet access to pull images for platform containers and provide telemetry data to Red Hat.

Table 23.3. Ports used for all-machine to all-machine communications

Protocol	Port	Description
ICMP	N/A	Network reachability tests
TCP	**1936**	Metrics
	9000-**9999**	Host level services, including the node exporter on ports **9100**-**9101** and the Cluster Version Operator on port**9099**.
	10250-**10259**	The default ports that Kubernetes reserves
	10256	openshift-sdn
UDP	**4789**	VXLAN
	6081	Geneve
	9000-**9999**	Host level services, including the node exporter on ports **9100**-**9101**.

Protocol	Port	Description
	500	IPsec IKE packets
	4500	IPsec NAT-T packets
TCP/UDP	**30000**-**32767**	Kubernetes node port
ESP	N/A	IPsec Encapsulating Security Payload (ESP)

Table 23.4. Ports used for all-machine to control plane communications

Protocol	Port	Description
TCP	**6443**	Kubernetes API

Table 23.5. Ports used for control plane machine to control plane machine communications

Protocol	Port	Description
TCP	**2379**-**2380**	etcd server and peer ports

NTP configuration for user-provisioned infrastructure
OpenShift Container Platform clusters are configured to use a public Network Time Protocol (NTP) server by default. If you want to use a local enterprise NTP server, or if your cluster is being deployed in a disconnected network, you can configure the cluster to use a specific time server. For more information, see the documentation for *Configuring chrony time service* .

If a DHCP server provides NTP server information, the chrony time service on the Red Hat Enterprise Linux CoreOS (RHCOS) machines read the information and can sync the clock with the NTP servers.

Additional resources

- Configuring chrony time service

23.1.3.5. User-provisioned DNS requirements

In OpenShift Container Platform deployments, DNS name resolution is required for the following components:

- The Kubernetes API
- The OpenShift Container Platform application wildcard
- The bootstrap, control plane, and compute machines

Reverse DNS resolution is also required for the Kubernetes API, the bootstrap machine, the control plane machines, and the compute machines.

DNS A/AAAA or CNAME records are used for name resolution and PTR records are used for reverse

name resolution. The reverse records are important because Red Hat Enterprise Linux CoreOS (RHCOS) uses the reverse records to set the hostnames for all the nodes, unless the hostnames are provided by DHCP. Additionally, the reverse records are used to generate the certificate signing requests (CSR) that OpenShift Container Platform needs to operate.

NOTE

It is recommended to use a DHCP server to provide the hostnames to each cluster node. See the *DHCP recommendations for user-provisioned infrastructure* section for more information.

The following DNS records are required for a user-provisioned OpenShift Container Platform cluster and they must be in place before installation. In each record, **<cluster_name>** is the cluster name and **<base_domain>** is the base domain that you specify in the **install-config.yaml** file. A complete DNS record takes the form: **<component>.<cluster_name>.<base_domain>.**.

Table 23.6. Required DNS records

Component	Record	Description
Kubernetes API	**api.<cluster_name>. <base_domain>.**	A DNS A/AAAA or CNAME record, and a DNS PTR record, to identify the API load balancer. These records must be resolvable by both clients external to the cluster and from all the nodes within the cluster.
	api-int.<cluster_name>. <base_domain>.	A DNS A/AAAA or CNAME record, and a DNS PTR record, to internally identify the API load balancer. These records must be resolvable from all the nodes within the cluster.  IMPORTANT The API server must be able to resolve the worker nodes by the hostnames that are recorded in Kubernetes. If the API server cannot resolve the node names, then proxied API calls can fail, and you cannot retrieve logs from pods.
Routes	***.apps.<cluster_name>. <base_domain>.**	A wildcard DNS A/AAAA or CNAME record that refers to the application ingress load balancer. The application ingress load balancer targets the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default. These records must be resolvable by both clients external to the cluster and from all the nodes within the cluster. For example, **console-openshift-console.apps. <cluster_name>.<base_domain>** is used as a wildcard route to the OpenShift Container Platform console.

Component	Record	Description
Bootstrap machine	**bootstrap.<cluster_name>.<base_domain>.**	A DNS A/AAAA or CNAME record, and a DNS PTR record, to identify the bootstrap machine. These records must be resolvable by the nodes within the cluster.
Control plane machines	**<master><n>.<cluster_name>.<base_domain>.**	DNS A/AAAA or CNAME records and DNS PTR records to identify each machine for the control plane nodes. These records must be resolvable by the nodes within the cluster.
Compute machines	**<worker><n>.<cluster_name>.<base_domain>.**	DNS A/AAAA or CNAME records and DNS PTR records to identify each machine for the worker nodes. These records must be resolvable by the nodes within the cluster.

NOTE

In OpenShift Container Platform 4.4 and later, you do not need to specify etcd host and SRV records in your DNS configuration.

TIP

You can use the **dig** command to verify name and reverse name resolution. See the section on *Validating DNS resolution for user-provisioned infrastructure* for detailed validation steps.

23.1.3.5.1. Example DNS configuration for user-provisioned clusters

This section provides A and PTR record configuration samples that meet the DNS requirements for deploying OpenShift Container Platform on user-provisioned infrastructure. The samples are not meant to provide advice for choosing one DNS solution over another.

In the examples, the cluster name is **ocp4** and the base domain is **example.com**.

Example DNS A record configuration for a user-provisioned cluster

The following example is a BIND zone file that shows sample A records for name resolution in a user-provisioned cluster.

Example 23.1. Sample DNS zone database

```
$TTL 1W
@ IN SOA ns1.example.com. root (
  2019070700 ; serial
  3H  ; refresh (3 hours)
  30M  ; retry (30 minutes)
  2W  ; expiry (2 weeks)
  1W )  ; minimum (1 week)
 IN NS ns1.example.com.
 IN MX 10 smtp.example.com.
```

```
;
;
ns1.example.com.  IN A 192.168.1.5
smtp.example.com.  IN A 192.168.1.5
;
helper.example.com.  IN A 192.168.1.5
helper.ocp4.example.com. IN A 192.168.1.5
;
api.ocp4.example.com.  IN A 192.168.1.5 1
api-int.ocp4.example.com. IN A 192.168.1.5 2
;
*.apps.ocp4.example.com. IN A 192.168.1.5 3
;
bootstrap.ocp4.example.com. IN A 192.168.1.96 4
;
master0.ocp4.example.com. IN A 192.168.1.97 5
master1.ocp4.example.com. IN A 192.168.1.98 6
master2.ocp4.example.com. IN A 192.168.1.99 7
;
worker0.ocp4.example.com. IN A 192.168.1.11 8
worker1.ocp4.example.com. IN A 192.168.1.7 9
;
;EOF
```

1 Provides name resolution for the Kubernetes API. The record refers to the IP address of the API load balancer.

2 Provides name resolution for the Kubernetes API. The record refers to the IP address of the API load balancer and is used for internal cluster communications.

3 Provides name resolution for the wildcard routes. The record refers to the IP address of the application ingress load balancer. The application ingress load balancer targets the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.

NOTE

In the example, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

4 Provides name resolution for the bootstrap machine.

5 6 7 Provides name resolution for the control plane machines.

8 9 Provides name resolution for the compute machines.

Example DNS PTR record configuration for a user-provisioned cluster

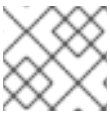
The following example BIND zone file shows sample PTR records for reverse name resolution in a user-provisioned cluster.

```
-
```

Example 23.2. Sample DNS zone database for reverse records

```
$TTL 1W
@ IN SOA ns1.example.com. root (
  2019070700 ; serial
  3H  ; refresh (3 hours)
  30M  ; retry (30 minutes)
  2W  ; expiry (2 weeks)
  1W )  ; minimum (1 week)
 IN NS ns1.example.com.
;
5.1.168.192.in-addr.arpa. IN PTR api.ocp4.example.com. 1
5.1.168.192.in-addr.arpa. IN PTR api-int.ocp4.example.com. 2
;
96.1.168.192.in-addr.arpa. IN PTR bootstrap.ocp4.example.com. 3
;
97.1.168.192.in-addr.arpa. IN PTR master0.ocp4.example.com. 4
98.1.168.192.in-addr.arpa. IN PTR master1.ocp4.example.com. 5
99.1.168.192.in-addr.arpa. IN PTR master2.ocp4.example.com. 6
;
11.1.168.192.in-addr.arpa. IN PTR worker0.ocp4.example.com. 7
7.1.168.192.in-addr.arpa. IN PTR worker1.ocp4.example.com. 8
;
;EOF
```

1. Provides reverse DNS resolution for the Kubernetes API. The PTR record refers to the record name of the API load balancer.
2. Provides reverse DNS resolution for the Kubernetes API. The PTR record refers to the record name of the API load balancer and is used for internal cluster communications.
3. Provides reverse DNS resolution for the bootstrap machine.
4. 5. 6. Provides reverse DNS resolution for the control plane machines.
7. 8. Provides reverse DNS resolution for the compute machines.

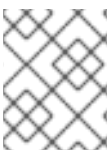


NOTE

A PTR record is not required for the OpenShift Container Platform application wildcard.

23.1.3.6. Load balancing requirements for user-provisioned infrastructure

Before you install OpenShift Container Platform, you must provision the API and application ingress load balancing infrastructure. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.



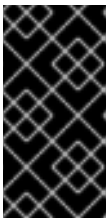
NOTE

If you want to deploy the API and application Ingress load balancers with a Red Hat Enterprise Linux (RHEL) instance, you must purchase the RHEL subscription separately.

The load balancing infrastructure must meet the following requirements:

1. **API load balancer**: Provides a common endpoint for users, both human and machine, to interact with and configure the platform. Configure the following conditions:

   - Layer 4 load balancing only. This can be referred to as Raw TCP, SSL Passthrough, or SSL Bridge mode. If you use SSL Bridge mode, you must enable Server Name Indication (SNI) for the API routes.
   - A stateless load balancing algorithm. The options vary based on the load balancer implementation.



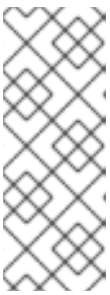
IMPORTANT

Do not configure session persistence for an API load balancer. Configuring session persistence for a Kubernetes API server might cause performance issues from excess application traffic for your OpenShift Container Platform cluster and the Kubernetes API that runs inside the cluster.

Configure the following ports on both the front and back of the load balancers:

Table 23.7. API load balancer

Port	Back-end machines (pool members)	Internal	External	Description
6443	Bootstrap and control plane. You remove the bootstrap machine from the load balancer after the bootstrap machine initializes the cluster control plane. You must configure the **/readyz** endpoint for the API server health check probe.	X	X	Kubernetes API server
22623	Bootstrap and control plane. You remove the bootstrap machine from the load balancer after the bootstrap machine initializes the cluster control plane.	X		Machine config server



NOTE

The load balancer must be configured to take a maximum of 30 seconds from the time the API server turns off the **/readyz** endpoint to the removal of the API server instance from the pool. Within the time frame after **/readyz** returns an error or becomes healthy, the endpoint must have been removed or added. Probing every 5 or 10 seconds, with two successful requests to become healthy and three to become unhealthy, are well-tested values.

2. **Application Ingress load balancer**: Provides an ingress point for application traffic flowing in from outside the cluster. A working configuration for the Ingress router is required for an OpenShift Container Platform cluster.
   Configure the following conditions:

- Layer 4 load balancing only. This can be referred to as Raw TCP, SSL Passthrough, or SSL Bridge mode. If you use SSL Bridge mode, you must enable Server Name Indication (SNI) for the ingress routes.
- A connection-based or session-based persistence is recommended, based on the options available and types of applications that will be hosted on the platform.

TIP

If the true IP address of the client can be seen by the application Ingress load balancer, enabling source IP-based session persistence can improve performance for applications that use end-to-end TLS encryption.

Configure the following ports on both the front and back of the load balancers:

Table 23.8. Application Ingress load balancer

Port	Back-end machines (pool members)	Internal	External	Description
443	The machines that run the Ingress Controller pods, compute, or worker, by default.	X	X	HTTPS traffic
80	The machines that run the Ingress Controller pods, compute, or worker, by default.	X	X	HTTP traffic

NOTE

If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application Ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes.

23.1.3.6.1. Example load balancer configuration for user-provisioned clusters

This section provides an example API and application ingress load balancer configuration that meets the load balancing requirements for user-provisioned clusters. The sample is an **/etc/haproxy/haproxy.cfg** configuration for an HAProxy load balancer. The example is not meant to provide advice for choosing one load balancing solution over another.

In the example, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

NOTE

If you are using HAProxy as a load balancer and SELinux is set to **enforcing**, you must ensure that the HAProxy service can bind to the configured TCP port by running **setsebool -P haproxy_connect_any=1**.

Example 23.3. Sample API and application Ingress load balancer configuration

```
global
  log         127.0.0.1 local2
  pidfile     /var/run/haproxy.pid
  maxconn     4000
  daemon
defaults
  mode                    http
  log                     global
  option                  dontlognull
  option http-server-close
  option                  redispatch
  retries                 3
  timeout http-request    10s
  timeout queue           1m
  timeout connect         10s
  timeout client          1m
  timeout server          1m
  timeout http-keep-alive 10s
  timeout check           10s
  maxconn                 3000
listen api-server-6443 (1)
  bind *:6443
  mode tcp
  server bootstrap bootstrap.ocp4.example.com:6443 check inter 1s backup (2)
  server master0 master0.ocp4.example.com:6443 check inter 1s
  server master1 master1.ocp4.example.com:6443 check inter 1s
  server master2 master2.ocp4.example.com:6443 check inter 1s
listen machine-config-server-22623 (3)
  bind *:22623
  mode tcp
  option  httpchk GET /readyz HTTP/1.0
  option  log-health-checks
  balance roundrobin
  server bootstrap bootstrap.ocp4.example.com:6443 verify none check check-ssl inter 10s fall 2
rise 3 backup (4)
  server master0 master0.ocp4.example.com:6443 weight 1 verify none check check-ssl inter 10s
fall 2 rise 3
  server master1 master1.ocp4.example.com:6443 weight 1 verify none check check-ssl inter 10s
fall 2 rise 3
  server master2 master2.ocp4.example.com:6443 weight 1 verify none check check-ssl inter 10s
fall 2 rise 3
listen ingress-router-443 (5)
  bind *:443
  mode tcp
  balance source
  server worker0 worker0.ocp4.example.com:443 check inter 1s
  server worker1 worker1.ocp4.example.com:443 check inter 1s
listen ingress-router-80 (6)
  bind *:80
  mode tcp
  balance source
  server worker0 worker0.ocp4.example.com:80 check inter 1s
  server worker1 worker1.ocp4.example.com:80 check inter 1s
```

(1) Port **6443** handles the Kubernetes API traffic and points to the control plane machines.

2 4 The bootstrap entries must be in place before the OpenShift Container Platform cluster installation and they must be removed after the bootstrap process is complete.

3 Port **22623** handles the machine config server traffic and points to the control plane machines.

5 Port **443** handles the HTTPS traffic and points to the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.

6 Port **80** handles the HTTP traffic and points to the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.

NOTE

If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application Ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes.

TIP

If you are using HAProxy as a load balancer, you can check that the **haproxy** process is listening on ports **6443**, **22623**, **443**, and **80** by running **netstat -nltupe** on the HAProxy node.

23.1.4. Preparing the user-provisioned infrastructure

Before you install OpenShift Container Platform on user-provisioned infrastructure, you must prepare the underlying infrastructure.

This section provides details about the high-level steps required to set up your cluster infrastructure in preparation for an OpenShift Container Platform installation. This includes configuring IP networking and network connectivity for your cluster nodes, enabling the required ports through your firewall, and setting up the required DNS and load balancing infrastructure.

After preparation, your cluster infrastructure must meet the requirements outlined in the *Requirements for a cluster with user-provisioned infrastructure* section.

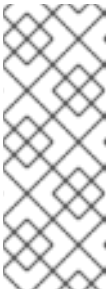
Prerequisites

- You have reviewed the OpenShift Container Platform 4.x Tested Integrations page.
- You have reviewed the infrastructure requirements detailed in the *Requirements for a cluster with user-provisioned infrastructure* section.

Procedure

1. If you are using DHCP to provide the IP networking configuration to your cluster nodes, configure your DHCP service.
   a. Add persistent IP addresses for the nodes to your DHCP server configuration. In your configuration, match the MAC address of the relevant network interface to the intended IP address for each node.

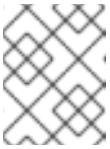
b. When you use DHCP to configure IP addressing for the cluster machines, the machines also obtain the DNS server information through DHCP. Define the persistent DNS server address that is used by the cluster nodes through your DHCP server configuration.



NOTE

If you are not using a DHCP service, you must provide the IP networking configuration and the address of the DNS server to the nodes at RHCOS install time. These can be passed as boot arguments if you are installing from an ISO image. See the *Installing RHCOS and starting the OpenShift Container Platform bootstrap process* section for more information about static IP provisioning and advanced networking options.

c. Define the hostnames of your cluster nodes in your DHCP server configuration. See the *Setting the cluster node hostnames through DHCP* section for details about hostname considerations.

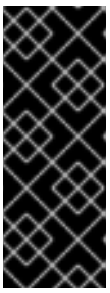


NOTE

If you are not using a DHCP service, the cluster nodes obtain their hostname through a reverse DNS lookup.

2. Ensure that your network infrastructure provides the required network connectivity between the cluster components. See the *Networking requirements for user-provisioned infrastructure* section for details about the requirements.

3. Configure your firewall to enable the ports required for the OpenShift Container Platform cluster components to communicate. See *Networking requirements for user-provisioned infrastructure* section for details about the ports that are required.



IMPORTANT

By default, port **1936** is accessible for an OpenShift Container Platform cluster, because each control plane node needs access to this port.

Avoid using the Ingress load balancer to expose this port, because doing so might result in the exposure of sensitive information, such as statistics and metrics, related to Ingress Controllers.

4. Setup the required DNS infrastructure for your cluster.

   a. Configure DNS name resolution for the Kubernetes API, the application wildcard, the bootstrap machine, the control plane machines, and the compute machines.

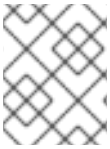
   b. Configure reverse DNS resolution for the Kubernetes API, the bootstrap machine, the control plane machines, and the compute machines.
   See the *User-provisioned DNS requirements* section for more information about the OpenShift Container Platform DNS requirements.

5. Validate your DNS configuration.

   a. From your installation node, run DNS lookups against the record names of the Kubernetes API, the wildcard routes, and the cluster nodes. Validate that the IP addresses in the responses correspond to the correct components.

b. From your installation node, run reverse DNS lookups against the IP addresses of the load balancer and the cluster nodes. Validate that the record names in the responses correspond to the correct components.
See the *Validating DNS resolution for user-provisioned infrastructure* section for detailed DNS validation steps.

6. Provision the required API and application ingress load balancing infrastructure. See the *Load balancing requirements for user-provisioned infrastructure* section for more information about the requirements.



NOTE

Some load balancing solutions require the DNS name resolution for the cluster nodes to be in place before the load balancing is initialized.

23.1.5. Validating DNS resolution for user-provisioned infrastructure

You can validate your DNS configuration before installing OpenShift Container Platform on user-provisioned infrastructure.

IMPORTANT

The validation steps detailed in this section must succeed before you install your cluster.

Prerequisites

- You have configured the required DNS records for your user-provisioned infrastructure.

Procedure

1. From your installation node, run DNS lookups against the record names of the Kubernetes API, the wildcard routes, and the cluster nodes. Validate that the IP addresses contained in the responses correspond to the correct components.

   a. Perform a lookup against the Kubernetes API record name. Check that the result points to the IP address of the API load balancer:

   ```
   $ dig +noall +answer @<nameserver_ip> api.<cluster_name>.<base_domain>
   ```
   (1)

   (1) Replace **<nameserver_ip>** with the IP address of the nameserver, **<cluster_name>** with your cluster name, and **<base_domain>** with your base domain name.

   Example output

   ```
   api.ocp4.example.com.  604800 IN A 192.168.1.5
   ```

   b. Perform a lookup against the Kubernetes internal API record name. Check that the result points to the IP address of the API load balancer:

   ```
   $ dig +noall +answer @<nameserver_ip> api-int.<cluster_name>.<base_domain>
   ```

   Example output

```
api-int.ocp4.example.com.  604800 IN A 192.168.1.5
```

c. Test an example ***.apps.<cluster_name>.<base_domain>** DNS wildcard lookup. All of the application wildcard lookups must resolve to the IP address of the application ingress load balancer:

```
$ dig +noall +answer @<nameserver_ip> random.apps.<cluster_name>.<base_domain>
```

Example output

```
random.apps.ocp4.example.com.  604800 IN A 192.168.1.5
```

NOTE

In the example outputs, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

You can replace **random** with another wildcard value. For example, you can query the route to the OpenShift Container Platform console:

```
$ dig +noall +answer @<nameserver_ip> console-openshift-console.apps.
<cluster_name>.<base_domain>
```

Example output

```
console-openshift-console.apps.ocp4.example.com. 604800 IN A 192.168.1.5
```

d. Run a lookup against the bootstrap DNS record name. Check that the result points to the IP address of the bootstrap node:

```
$ dig +noall +answer @<nameserver_ip> bootstrap.<cluster_name>.<base_domain>
```

Example output

```
bootstrap.ocp4.example.com.  604800 IN A 192.168.1.96
```

e. Use this method to perform lookups against the DNS record names for the control plane and compute nodes. Check that the results correspond to the IP addresses of each node.

2. From your installation node, run reverse DNS lookups against the IP addresses of the load balancer and the cluster nodes. Validate that the record names contained in the responses correspond to the correct components.

a. Perform a reverse lookup against the IP address of the API load balancer. Check that the response includes the record names for the Kubernetes API and the Kubernetes internal API:

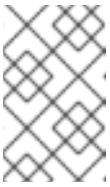
```
$ dig +noall +answer @<nameserver_ip> -x 192.168.1.5
```

Example output

```
5.1.168.192.in-addr.arpa. 604800 IN PTR api-int.ocp4.example.com. 1
5.1.168.192.in-addr.arpa. 604800 IN PTR api.ocp4.example.com. 2
```

1 Provides the record name for the Kubernetes internal API.

2 Provides the record name for the Kubernetes API.



NOTE

A PTR record is not required for the OpenShift Container Platform application wildcard. No validation step is needed for reverse DNS resolution against the IP address of the application ingress load balancer.

b. Perform a reverse lookup against the IP address of the bootstrap node. Check that the result points to the DNS record name of the bootstrap node:

```
$ dig +noall +answer @<nameserver_ip> -x 192.168.1.96
```

Example output

```
96.1.168.192.in-addr.arpa. 604800 IN PTR bootstrap.ocp4.example.com.
```

c. Use this method to perform reverse lookups against the IP addresses for the control plane and compute nodes. Check that the results correspond to the DNS record names of each node.

23.1.6. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the **~/.ssh/authorized_keys** list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The **./openshift-install gather** command also requires the SSH public key to be in place on the cluster nodes.

IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.

NOTE

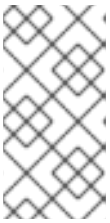
You must use a local key, not one that you configured with platform-specific approaches such as AWS key pairs.

Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N '' -f <path>/<file_name> 1
```

1 Specify the path and file name, such as ~/**.ssh/id_ed25519**, of the new SSH key. If you have an existing key pair, ensure your public key is in the your ~/**.ssh** directory.



NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS validated or Modules In Process cryptographic libraries on the **x86_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the ~/**.ssh/id_ed25519.pub** public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the **./openshift-install gather** command.

NOTE

On some distributions, default SSH private key identities such as ~/**.ssh/id_rsa** and ~/**.ssh/id_dsa** are managed automatically.

a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

Example output

```
Agent pid 31874
```

NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

1 Specify the path and file name for your SSH private key, such as **~/.ssh/id_ed25519**

Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program. If you install a cluster on infrastructure that you provision, you must provide the key to the installation program.

23.1.7. Obtaining the installation program

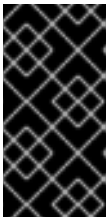
Before you install OpenShift Container Platform, download the installation file on a local computer.

Prerequisites

- You have a computer that runs Linux or macOS, with 500 MB of local disk space.

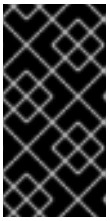
Procedure

1. Access the Infrastructure Provider page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program that corresponds with your host operating system and architecture, and place the file in the directory where you will store the installation configuration files.



IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.



IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

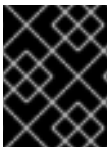
4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation pull secret from the Red Hat OpenShift Cluster Manager . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

23.1.8. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.



IMPORTANT

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.11. Download and install the new version of **oc**.

Installing the OpenShift CLI on Linux

You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the architecture in the **Product Variant** drop-down menu.
3. Select the appropriate version in the **Version** drop-down menu.
4. Click **Download Now** next to the **OpenShift v4.11 Linux Client** entry and save the file.
5. Unpack the archive:

```
$ tar xvf <file>
```

6. Place the **oc** binary in a directory that is on your **PATH**.
   To check your **PATH**, execute the following command:

```
$ echo $PATH
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.
   To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

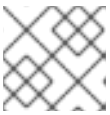
```
C:\> oc <command>
```

Installing the OpenShift CLI on macOS

You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

Procedure

1. Navigate to the OpenShift Container Platform downloads page on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.11 macOS Client** entry and save the file.



NOTE

For macOS arm64, choose the **OpenShift v4.11 macOS arm64 Client** entry.

4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your PATH.
   To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

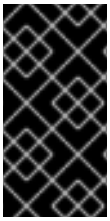
Verification

- After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

23.1.9. Manually creating the installation configuration file

For user-provisioned installations of OpenShift Container Platform, you manually generate your installation configuration file.



IMPORTANT

The Cluster Cloud Controller Manager Operator performs a connectivity check on a provided hostname or IP address. Ensure that you specify a hostname or an IP address to a reachable vCenter server. If you provide metadata to a non-existent vCenter server, installation of the cluster fails at the bootstrap stage.

Prerequisites

- You have an SSH public key on your local machine to provide to the installation program. The key will be used for SSH authentication onto your cluster nodes for debugging and disaster recovery.
- You have obtained the OpenShift Container Platform installation program and the pull secret for your cluster.
- Obtain the **imageContentSources** section from the output of the command to mirror the repository.
- Obtain the contents of the certificate for your mirror registry.

Procedure

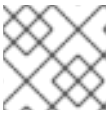
1. Create an installation directory to store your required installation assets in:

```
$ mkdir <installation_directory>
```

IMPORTANT

You must create a directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

2. Customize the sample **install-config.yaml** file template that is provided and save it in the **<installation_directory>**.



NOTE

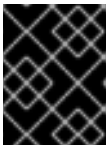
You must name this configuration file **install-config.yaml**.

- Unless you use a registry that RHCOS trusts by default, such as **docker.io**, you must provide the contents of the certificate for your mirror repository in the **additionalTrustBundle** section. In most cases, you must provide the certificate for your mirror.
- You must include the **imageContentSources** section from the output of the command to mirror the repository.

NOTE

For some platform types, you can alternatively run **./openshift-install create install-config --dir <installation_directory>** to generate an **install-config.yaml** file. You can provide details about your cluster configuration at the prompts.

3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.



IMPORTANT

The **install-config.yaml** file is consumed during the next step of the installation process. You must back it up now.

23.1.9.1. Sample install-config.yaml file for other platforms

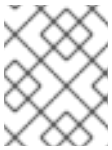
You can customize the **install-config.yaml** file to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.

```
apiVersion: v1
baseDomain: example.com (1)
compute: (2)
- hyperthreading: Enabled (3)
  name: worker
  replicas: 0 (4)
controlPlane: (5)
  hyperthreading: Enabled (6)
  name: master
  replicas: 3 (7)
metadata:
  name: test (8)
networking:
  clusterNetwork:
  - cidr: 10.128.0.0/14 (9)
    hostPrefix: 23 (10)
  networkType: OpenShiftSDN
  serviceNetwork: (11)
  - 172.30.0.0/16
platform:
  none: {} (12)
fips: false (13)
pullSecret: '{"auths": ...}' (14)
sshKey: 'ssh-ed25519 AAAA...' (15)
```

1 The base domain of the cluster. All DNS records must be sub-domains of this base and include the cluster name.

2 5 The **controlPlane** section is a single mapping, but the **compute** section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, **-**, and the first line of the **controlPlane** section must not. Only one control plane pool is used.

3 6 Specifies whether to enable or disable simultaneous multithreading (SMT), or hyperthreading. By default, SMT is enabled to increase the performance of the cores in your machines. You can disable it by setting the parameter value to **Disabled**. If you disable SMT, you must disable it in all cluster machines; this includes both control plane and compute machines.



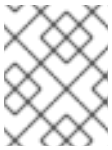
NOTE

Simultaneous multithreading (SMT) is enabled by default. If SMT is not enabled in your BIOS settings, the **hyperthreading** parameter has no effect.

IMPORTANT

If you disable **hyperthreading**, whether in the BIOS or in the **install-config.yaml** file, ensure that your capacity planning accounts for the dramatically decreased machine performance.

4 You must set this value to **0** when you install OpenShift Container Platform on user-provisioned infrastructure. In installer-provisioned installations, the parameter controls the number of compute machines that the cluster creates and manages for you. In user-provisioned installations, you must manually deploy the compute machines before you finish installing the cluster.



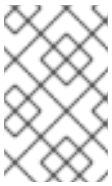
NOTE

If you are installing a three-node cluster, do not deploy any compute machines when you install the Red Hat Enterprise Linux CoreOS (RHCOS) machines.

7 The number of control plane machines that you add to the cluster. Because the cluster uses these values as the number of etcd endpoints in the cluster, the value must match the number of control plane machines that you deploy.

8 The cluster name that you specified in your DNS records.

9 A block of IP addresses from which pod IP addresses are allocated. This block must not overlap with existing physical networks. These IP addresses are used for the pod network. If you need to access the pods from an external network, you must configure load balancers and routers to manage the traffic.



NOTE

Class E CIDR range is reserved for a future use. To use the Class E CIDR range, you must ensure your networking environment accepts the IP addresses within the Class E CIDR range.

10 The subnet prefix length to assign to each individual node. For example, if **hostPrefix** is set to **23**, then each node is assigned a /**23** subnet out of the given **cidr**, which allows for 510 (2^(32 - 23) - 2) pod IP addresses. If you are required to provide access to nodes from an external network,

configure load balancers and routers to manage the traffic.

11 The IP address pool to use for service IP addresses. You can enter only one IP address pool. This block must not overlap with existing physical networks. If you need to access the services from an external network, configure load balancers and routers to manage the traffic.

12 You must set the platform to **none**. You cannot provide additional platform configuration variables for your platform.

IMPORTANT

Clusters that are installed with the platform type **none** are unable to use some features, such as managing compute machines with the Machine API. This limitation applies even if the compute machines that are attached to the cluster are installed on a platform that would normally support the feature. This parameter cannot be changed after installation.

13 Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.

IMPORTANT

To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode. The use of FIPS validated or Modules In Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.

14 The pull secret from the Red Hat OpenShift Cluster Manager . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

15 The SSH public key for the **core** user in Red Hat Enterprise Linux CoreOS (RHCOS).

NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

23.1.9.2. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

Prerequisites

- You have an existing **install-config.yaml** file.

- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.

NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

Procedure

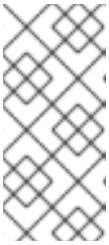
1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
```

1. A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
2. A proxy URL to use for creating HTTPS connections outside the cluster.
3. A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use ***** to bypass the proxy for all destinations.
4. If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace that contains one or more additional CA certificates that are required for proxying HTTPS connections. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges these contents with the Red Hat Enterprise Linux CoreOS (RHCOS) trust bundle, and this config map is referenced in the **trustedCA** field of the **Proxy** object. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.

NOTE

The installation program does not support the proxy **readinessEndpoints** field.



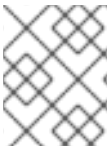
NOTE

If the installer times out, restart and then complete the deployment by using the **wait-for** command of the installer. For example:

```
$ ./openshift-install wait-for install-complete --log-level debug
```

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.



NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

23.1.9.3. Configuring a three-node cluster

Optionally, you can deploy zero compute machines in a bare metal cluster that consists of three control plane machines only. This provides smaller, more resource efficient clusters for cluster administrators and developers to use for testing, development, and production.

In three-node OpenShift Container Platform environments, the three control plane machines are schedulable, which means that your application workloads are scheduled to run on them.

Prerequisites

- You have an existing **install-config.yaml** file.

Procedure

- Ensure that the number of compute replicas is set to **0** in your **install-config.yaml** file, as shown in the following **compute** stanza:

```
compute:
- name: worker
  platform: {}
  replicas: 0
```

NOTE

You must set the value of the **replicas** parameter for the compute machines to **0** when you install OpenShift Container Platform on user-provisioned infrastructure, regardless of the number of compute machines you are deploying. In installer-provisioned installations, the parameter controls the number of compute machines that the cluster creates and manages for you. This does not apply to user-provisioned installations, where the compute machines are deployed manually.

For three-node cluster installations, follow these next steps:

- If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes. See the *Load balancing requirements for user-provisioned infrastructure* section for more information.
- When you create the Kubernetes manifest files in the following procedure, ensure that the **mastersSchedulable** parameter in the **<installation_directory>/manifests/cluster-scheduler-02-config.yml** file is set to **true**. This enables your application workloads to run on the control plane nodes.
- Do not deploy any compute nodes when you create the Red Hat Enterprise Linux CoreOS (RHCOS) machines.

23.1.10. Creating the Kubernetes manifest and Ignition config files

Because you must modify some cluster definition files and manually start the cluster machines, you must generate the Kubernetes manifest and Ignition config files that the cluster needs to configure the machines.

The installation configuration file transforms into the Kubernetes manifests. The manifests wrap into the Ignition configuration files, which are later used to configure the cluster machines.

IMPORTANT

- The Ignition config files that the OpenShift Container Platform installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

Prerequisites

- You obtained the OpenShift Container Platform installation program.
- You created the **install-config.yaml** installation configuration file.

Procedure

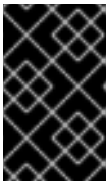
1. Change to the directory that contains the OpenShift Container Platform installation program and generate the Kubernetes manifests for the cluster:

```
$ ./openshift-install create manifests --dir <installation_directory> 1
```

1 For **<installation_directory>**, specify the installation directory that contains the **install-config.yaml** file you created.

WARNING

If you are installing a three-node cluster, skip the following step to allow the control plane nodes to be schedulable.



IMPORTANT

When you configure control plane nodes from the default unschedulable to schedulable, additional subscriptions are required. This is because control plane nodes then become compute nodes.

2. Check that the **mastersSchedulable** parameter in the **<installation_directory>/manifests/cluster-scheduler-02-config.yml** Kubernetes manifest file is set to **false**. This setting prevents pods from being scheduled on the control plane machines:

   a. Open the **<installation_directory>/manifests/cluster-scheduler-02-config.yml** file.

   b. Locate the **mastersSchedulable** parameter and ensure that it is set to **false**.

   c. Save and exit the file.

3. To create the Ignition configuration files, run the following command from the directory that contains the installation program:

```
$ ./openshift-install create ignition-configs --dir <installation_directory> 1
```

1 For **<installation_directory>**, specify the same installation directory.

Ignition config files are created for the bootstrap, control plane, and compute nodes in the installation directory. The **kubeadmin-password** and **kubeconfig** files are created in the **./<installation_directory>/auth** directory:

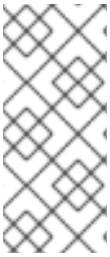
```
.
├── auth
│   ├── kubeadmin-password
│   └── kubeconfig
├── bootstrap.ign
├── master.ign
├── metadata.json
└── worker.ign
```

23.1.11. Installing RHCOS and starting the OpenShift Container Platform bootstrap process

To install OpenShift Container Platform on bare metal infrastructure that you provision, you must install Red Hat Enterprise Linux CoreOS (RHCOS) on the machines. When you install RHCOS, you must provide the Ignition config file that was generated by the OpenShift Container Platform installation

program for the type of machine you are installing. If you have configured suitable networking, DNS, and load balancing infrastructure, the OpenShift Container Platform bootstrap process begins automatically after the RHCOS machines have rebooted.

To install RHCOS on the machines, follow either the steps to use an ISO image or network PXE booting.



NOTE

The compute node deployment steps included in this installation document are RHCOS-specific. If you choose instead to deploy RHEL-based compute nodes, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks. Only RHEL 8 compute machines are supported.

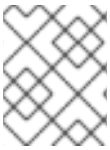
You can configure RHCOS during ISO and PXE installations by using the following methods:

- Kernel arguments: You can use kernel arguments to provide installation-specific information. For example, you can specify the locations of the RHCOS installation files that you uploaded to your HTTP server and the location of the Ignition config file for the type of node you are installing. For a PXE installation, you can use the **APPEND** parameter to pass the arguments to the kernel of the live installer. For an ISO installation, you can interrupt the live installation boot process to add the kernel arguments. In both installation cases, you can use special **coreos.inst.*** arguments to direct the live installer, as well as standard installation boot arguments for turning standard kernel services on or off.

- Ignition configs: OpenShift Container Platform Ignition config files (***.ign**) are specific to the type of node you are installing. You pass the location of a bootstrap, control plane, or compute node Ignition config file during the RHCOS installation so that it takes effect on first boot. In special cases, you can create a separate, limited Ignition config to pass to the live system. That Ignition config could do a certain set of tasks, such as reporting success to a provisioning system after completing installation. This special Ignition config is consumed by the **coreos-installer** to be applied on first boot of the installed system. Do not provide the standard control plane and compute node Ignition configs to the live ISO directly.

- **coreos-installer**: You can boot the live ISO installer to a shell prompt, which allows you to prepare the permanent system in a variety of ways before first boot. In particular, you can run the **coreos-installer** command to identify various artifacts to include, work with disk partitions, and set up networking. In some cases, you can configure features on the live system and copy them to the installed system.

Whether to use an ISO or PXE install depends on your situation. A PXE install requires an available DHCP service and more preparation, but can make the installation process more automated. An ISO install is a more manual process and can be inconvenient if you are setting up more than a few machines.



NOTE

As of OpenShift Container Platform 4.6, the RHCOS ISO and other installation artifacts provide support for installation on disks with 4K sectors.

23.1.11.1. Installing RHCOS by using an ISO image

You can use an ISO image to install RHCOS on the machines.

Prerequisites

- You have created the Ignition config files for your cluster.
- You have configured suitable network, DNS and load balancing infrastructure.
- You have an HTTP server that can be accessed from your computer, and from the machines that you create.
- You have reviewed the *Advanced RHCOS installation configuration* section for different ways to configure features, such as networking and disk partitioning.

Procedure

1. Obtain the SHA512 digest for each of your Ignition config files. For example, you can use the following on a system running Linux to get the SHA512 digest for your **bootstrap.ign** Ignition config file:

```
$ sha512sum <installation_directory>/bootstrap.ign
```

   The digests are provided to the **coreos-installer** in a later step to validate the authenticity of the Ignition config files on the cluster nodes.

2. Upload the bootstrap, control plane, and compute node Ignition config files that the installation program created to your HTTP server. Note the URLs of these files.

IMPORTANT

You can add or change configuration settings in your Ignition configs before saving them to your HTTP server. If you plan to add more compute machines to your cluster after you finish installation, do not delete these files.

3. From the installation host, validate that the Ignition config files are available on the URLs. The following example gets the Ignition config file for the bootstrap node:

```
$ curl -k http://<HTTP_server>/bootstrap.ign 1
```

Example output

```
  % Total    % Received % Xferd  Average Speed   Time    Time     Time  Current
                                 Dload  Upload   Total   Spent    Left  Speed
  0     0    0     0    0     0      0      0 --:--:-- --:--:-- --:--:--     0{"ignition":
{"version":"3.2.0"},"passwd":{"users":[{"name":"core","sshAuthorizedKeys":["ssh-rsa...
```

   Replace **bootstrap.ign** with **master.ign** or **worker.ign** in the command to validate that the Ignition config files for the control plane and compute nodes are also available.

4. Although it is possible to obtain the RHCOS images that are required for your preferred method of installing operating system instances from the RHCOS image mirror page, the recommended way to obtain the correct version of your RHCOS images are from the output of **openshift-install** command:

```
$ openshift-install coreos print-stream-json | grep '\.iso[^.]'
```

Example output

```
"
```

```
"location": "<url>/art/storage/releases/rhcos-4.11-aarch64/<release>/aarch64/rhcos-
<release>-live.aarch64.iso",
"location": "<url>/art/storage/releases/rhcos-4.11-ppc64le/<release>/ppc64le/rhcos-
<release>-live.ppc64le.iso",
"location": "<url>/art/storage/releases/rhcos-4.11-s390x/<release>/s390x/rhcos-<release>-
live.s390x.iso",
"location": "<url>/art/storage/releases/rhcos-4.11/<release>/x86_64/rhcos-<release>-
live.x86_64.iso",
```

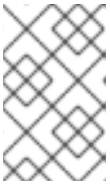
IMPORTANT

The RHCOS images might not change with every release of OpenShift Container Platform. You must download images with the highest version that is less than or equal to the OpenShift Container Platform version that you install. Use the image versions that match your OpenShift Container Platform version if they are available. Use only ISO images for this procedure. RHCOS qcow2 images are not supported for this installation type.

ISO file names resemble the following example:

rhcos-<version>-live.<architecture>.iso

5. Use the ISO to start the RHCOS installation. Use one of the following installation options:
   - Burn the ISO image to a disk and boot it directly.
   - Use ISO redirection by using a lights-out management (LOM) interface.
6. Boot the RHCOS ISO image without specifying any options or interrupting the live boot sequence. Wait for the installer to boot into a shell prompt in the RHCOS live environment.



NOTE

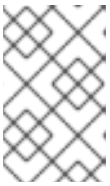
It is possible to interrupt the RHCOS installation boot process to add kernel arguments. However, for this ISO procedure you should use the **coreos-installer** command as outlined in the following steps, instead of adding kernel arguments.

7. Run the **coreos-installer** command and specify the options that meet your installation requirements. At a minimum, you must specify the URL that points to the Ignition config file for the node type, and the device that you are installing to:

```
$ sudo coreos-installer install --ignition-url=http://<HTTP_server>/<node_type>.ign <device>
--ignition-hash=sha512-<digest> 1 2
```

1 1 You must run the **coreos-installer** command by using **sudo**, because the **core** user does not have the required root privileges to perform the installation.

2 The **--ignition-hash** option is required when the Ignition config file is obtained through an HTTP URL to validate the authenticity of the Ignition config file on the cluster node. **<digest>** is the Ignition config file SHA512 digest obtained in a preceding step.



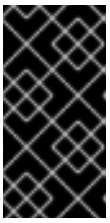
NOTE

If you want to provide your Ignition config files through an HTTPS server that uses TLS, you can add the internal certificate authority (CA) to the system trust store before running **coreos-installer**.

The following example initializes a bootstrap node installation to the **/dev/sda** device. The Ignition config file for the bootstrap node is obtained from an HTTP web server with the IP address 192.168.1.2:

```
$ sudo coreos-installer install --ignition-
url=http://192.168.1.2:80/installation_directory/bootstrap.ign /dev/sda --ignition-hash=sha512-
a5a2d43879223273c9b60af66b44202a1d1248fc01cf156c46d4a79f552b6bad47bc8cc78ddf011
6e80c59d2ea9e32ba53bc807afbca581aa059311def2c3e3b
```

8. Monitor the progress of the RHCOS installation on the console of the machine.



IMPORTANT

Be sure that the installation is successful on each node before commencing with the OpenShift Container Platform installation. Observing the installation process can also help to determine the cause of RHCOS installation issues that might arise.

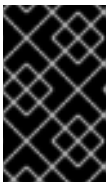
9. After RHCOS installs, you must reboot the system. During the system reboot, it applies the Ignition config file that you specified.

10. Check the console output to verify that Ignition ran.

Example command

```
Ignition: ran on 2022/03/14 14:48:33 UTC (this boot)
Ignition: user-provided config was applied
```

11. Continue to create the other machines for your cluster.



IMPORTANT

You must create the bootstrap and control plane machines at this time. If the control plane machines are not made schedulable, also create at least two compute machines before you install OpenShift Container Platform.

If the required network, DNS, and load balancer infrastructure are in place, the OpenShift Container Platform bootstrap process begins automatically after the RHCOS nodes have rebooted.

NOTE

RHCOS nodes do not include a default password for the **core** user. You can access the nodes by running **ssh core@<node>.<cluster_name>.<base_domain>** as a user with access to the SSH private key that is paired to the public key that you specified in your **install_config.yaml** file. OpenShift Container Platform 4 cluster nodes running RHCOS are immutable and rely on Operators to apply cluster changes. Accessing cluster nodes by using SSH is not recommended. However, when investigating installation issues, if the OpenShift Container Platform API is not available, or the kubelet is not properly functioning on a target node, SSH access might be required for debugging or disaster recovery.

23.1.11.2. Installing RHCOS by using PXE or iPXE booting

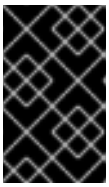
You can use PXE or iPXE booting to install RHCOS on the machines.

Prerequisites

- You have created the Ignition config files for your cluster.
- You have configured suitable network, DNS and load balancing infrastructure.
- You have configured suitable PXE or iPXE infrastructure.
- You have an HTTP server that can be accessed from your computer, and from the machines that you create.
- You have reviewed the *Advanced RHCOS installation configuration* section for different ways to configure features, such as networking and disk partitioning.

Procedure

1. Upload the bootstrap, control plane, and compute node Ignition config files that the installation program created to your HTTP server. Note the URLs of these files.



IMPORTANT

You can add or change configuration settings in your Ignition configs before saving them to your HTTP server. If you plan to add more compute machines to your cluster after you finish installation, do not delete these files.

2. From the installation host, validate that the Ignition config files are available on the URLs. The following example gets the Ignition config file for the bootstrap node:

```
$ curl -k http://<HTTP_server>/bootstrap.ign 1
```

Example output

```
  % Total    % Received % Xferd  Average Speed   Time    Time     Time  Current
                                 Dload  Upload   Total   Spent    Left  Speed
  0     0    0     0    0     0      0      0 --:--:-- --:--:-- --:--:--     0{"ignition":
{"version":"3.2.0"},"passwd":{"users":[{"name":"core","sshAuthorizedKeys":["ssh-rsa...
```

Replace **bootstrap.ign** with **master.ign** or **worker.ign** in the command to validate that the Ignition config files for the control plane and compute nodes are also available.

3. Although it is possible to obtain the RHCOS **kernel**, **initramfs** and **rootfs** files that are required for your preferred method of installing operating system instances from the RHCOS image mirror page, the recommended way to obtain the correct version of your RHCOS files are from the output of **openshift-install** command:

```
$ openshift-install coreos print-stream-json | grep -Eo '"https.*(kernel-|initramfs.|rootfs.)\w+(\.img)?"'
```

Example output

```
"<url>/art/storage/releases/rhcos-4.11-aarch64/<release>/aarch64/rhcos-<release>-live-kernel-aarch64"
"<url>/art/storage/releases/rhcos-4.11-aarch64/<release>/aarch64/rhcos-<release>-live-initramfs.aarch64.img"
"<url>/art/storage/releases/rhcos-4.11-aarch64/<release>/aarch64/rhcos-<release>-live-rootfs.aarch64.img"
"<url>/art/storage/releases/rhcos-4.11-ppc64le/49.84.202110081256-0/ppc64le/rhcos-<release>-live-kernel-ppc64le"
"<url>/art/storage/releases/rhcos-4.11-ppc64le/<release>/ppc64le/rhcos-<release>-live-initramfs.ppc64le.img"
"<url>/art/storage/releases/rhcos-4.11-ppc64le/<release>/ppc64le/rhcos-<release>-live-rootfs.ppc64le.img"
"<url>/art/storage/releases/rhcos-4.11-s390x/<release>/s390x/rhcos-<release>-live-kernel-s390x"
"<url>/art/storage/releases/rhcos-4.11-s390x/<release>/s390x/rhcos-<release>-live-initramfs.s390x.img"
"<url>/art/storage/releases/rhcos-4.11-s390x/<release>/s390x/rhcos-<release>-live-rootfs.s390x.img"
"<url>/art/storage/releases/rhcos-4.11/<release>/x86_64/rhcos-<release>-live-kernel-x86_64"
"<url>/art/storage/releases/rhcos-4.11/<release>/x86_64/rhcos-<release>-live-initramfs.x86_64.img"
"<url>/art/storage/releases/rhcos-4.11/<release>/x86_64/rhcos-<release>-live-rootfs.x86_64.img"
```

IMPORTANT

The RHCOS artifacts might not change with every release of OpenShift Container Platform. You must download images with the highest version that is less than or equal to the OpenShift Container Platform version that you install. Only use the appropriate **kernel**, **initramfs**, and **rootfs** artifacts described below for this procedure. RHCOS QCOW2 images are not supported for this installation type.

The file names contain the OpenShift Container Platform version number. They resemble the following examples:

- **kernel**: **rhcos-<version>-live-kernel-<architecture>**
- **initramfs**: **rhcos-<version>-live-initramfs.<architecture>.img**

- **rootfs**: **rhcos-<version>-live-rootfs.<architecture>.img**

4. Upload the **rootfs**, **kernel**, and **initramfs** files to your HTTP server.

IMPORTANT

If you plan to add more compute machines to your cluster after you finish installation, do not delete these files.

5. Configure the network boot infrastructure so that the machines boot from their local disks after RHCOS is installed on them.

6. Configure PXE or iPXE installation for the RHCOS images and begin the installation.
Modify one of the following example menu entries for your environment and verify that the image and Ignition files are properly accessible:

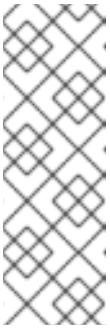
- For PXE (**x86_64**):

```
DEFAULT pxeboot
TIMEOUT 20
PROMPT 0
LABEL pxeboot
    KERNEL http://<HTTP_server>/rhcos-<version>-live-kernel-<architecture> 1
    APPEND initrd=http://<HTTP_server>/rhcos-<version>-live-initramfs.
<architecture>.img coreos.live.rootfs_url=http://<HTTP_server>/rhcos-<version>-live-
rootfs.<architecture>.img coreos.inst.install_dev=/dev/sda
coreos.inst.ignition_url=http://<HTTP_server>/bootstrap.ign 2 3
```

1 1 Specify the location of the live **kernel** file that you uploaded to your HTTP server. The URL must be HTTP, TFTP, or FTP; HTTPS and NFS are not supported.

2 If you use multiple NICs, specify a single interface in the **ip** option. For example, to use DHCP on a NIC that is named **eno1**, set **ip=eno1:dhcp**.

3 Specify the locations of the RHCOS files that you uploaded to your HTTP server. The **initrd** parameter value is the location of the **initramfs** file, the **coreos.live.rootfs_url** parameter value is the location of the **rootfs** file, and the **coreos.inst.ignition_url** parameter value is the location of the bootstrap Ignition config file. You can also add more kernel arguments to the **APPEND** line to configure networking or other boot options.



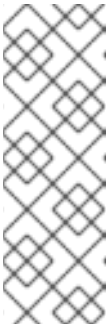
NOTE

This configuration does not enable serial console access on machines with a graphical console. To configure a different console, add one or more **console=** arguments to the **APPEND** line. For example, add **console=tty0 console=ttyS0** to set the first PC serial port as the primary console and the graphical console as a secondary console. For more information, see How does one set up a serial terminal and/or console in Red Hat Enterprise Linux?.

- For iPXE (**x86_64** + **aarch64**):

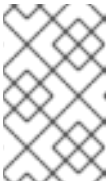
```
kernel http://<HTTP_server>/rhcos-<version>-live-kernel-<architecture> initrd=main
coreos.live.rootfs_url=http://<HTTP_server>/rhcos-<version>-live-rootfs.
<architecture>.img coreos.inst.install_dev=/dev/sda
coreos.inst.ignition_url=http://<HTTP_server>/bootstrap.ign 1 2
initrd --name main http://<HTTP_server>/rhcos-<version>-live-initramfs.
<architecture>.img 3
boot
```

1. Specify the locations of the RHCOS files that you uploaded to your HTTP server. The **kernel** parameter value is the location of the **kernel** file, the **initrd=main** argument is needed for booting on UEFI systems, the **coreos.live.rootfs_url** parameter value is the location of the **rootfs** file, and the **coreos.inst.ignition_url** parameter value is the location of the bootstrap Ignition config file.
2. If you use multiple NICs, specify a single interface in the **ip** option. For example, to use DHCP on a NIC that is named **eno1**, set **ip=eno1:dhcp**.
3. Specify the location of the **initramfs** file that you uploaded to your HTTP server.



NOTE

This configuration does not enable serial console access on machines with a graphical console. To configure a different console, add one or more **console=** arguments to the **kernel** line. For example, add **console=tty0 console=ttyS0** to set the first PC serial port as the primary console and the graphical console as a secondary console. For more information, see How does one set up a serial terminal and/or console in Red Hat Enterprise Linux?.



NOTE

To network boot the CoreOS **kernel** on **aarch64** architecture, you need to use a version of iPXE build with the **IMAGE_GZIP** option enabled. See **IMAGE_GZIP** option in iPXE .

- For PXE (with UEFI and Grub as second stage) on **aarch64**:

```
menuentry 'Install CoreOS' {
    linux rhcos-<version>-live-kernel-<architecture>
coreos.live.rootfs_url=http://<HTTP_server>/rhcos-<version>-live-rootfs.
<architecture>.img coreos.inst.install_dev=/dev/sda
coreos.inst.ignition_url=http://<HTTP_server>/bootstrap.ign 1 2
    initrd rhcos-<version>-live-initramfs.<architecture>.img 3
}
```

1. Specify the locations of the RHCOS files that you uploaded to your HTTP/TFTP server. The **kernel** parameter value is the location of the **kernel** file on your TFTP server. The **coreos.live.rootfs_url** parameter value is the location of the **rootfs** file, and the **coreos.inst.ignition_url** parameter value is the location of the bootstrap Ignition config file on your HTTP Server.
2. If you use multiple NICs, specify a single interface in the **ip** option. For example, to use DHCP on a NIC that is named **eno1**, set **ip=eno1:dhcp**.

3 Specify the location of the **initramfs** file that you uploaded to your TFTP server.

7. Monitor the progress of the RHCOS installation on the console of the machine.

IMPORTANT

Be sure that the installation is successful on each node before commencing with the OpenShift Container Platform installation. Observing the installation process can also help to determine the cause of RHCOS installation issues that might arise.

8. After RHCOS installs, the system reboots. During reboot, the system applies the Ignition config file that you specified.

9. Check the console output to verify that Ignition ran.

Example command

```
Ignition: ran on 2022/03/14 14:48:33 UTC (this boot)
Ignition: user-provided config was applied
```

10. Continue to create the machines for your cluster.

IMPORTANT

You must create the bootstrap and control plane machines at this time. If the control plane machines are not made schedulable, also create at least two compute machines before you install the cluster.

If the required network, DNS, and load balancer infrastructure are in place, the OpenShift Container Platform bootstrap process begins automatically after the RHCOS nodes have rebooted.

NOTE

RHCOS nodes do not include a default password for the **core** user. You can access the nodes by running **ssh core@<node>.<cluster_name>.<base_domain>** as a user with access to the SSH private key that is paired to the public key that you specified in your **install_config.yaml** file. OpenShift Container Platform 4 cluster nodes running RHCOS are immutable and rely on Operators to apply cluster changes. Accessing cluster nodes by using SSH is not recommended. However, when investigating installation issues, if the OpenShift Container Platform API is not available, or the kubelet is not properly functioning on a target node, SSH access might be required for debugging or disaster recovery.

23.1.11.3. Advanced RHCOS installation configuration

A key benefit for manually provisioning the Red Hat Enterprise Linux CoreOS (RHCOS) nodes for OpenShift Container Platform is to be able to do configuration that is not available through default OpenShift Container Platform installation methods. This section describes some of the configurations that you can do using techniques that include:

- Passing kernel arguments to the live installer
- Running **coreos-installer** manually from the live system
- Customizing a live ISO or PXE boot image

The advanced configuration topics for manual Red Hat Enterprise Linux CoreOS (RHCOS) installations detailed in this section relate to disk partitioning, networking, and using Ignition configs in different ways.

23.1.11.3.1. Using advanced networking options for PXE and ISO installations

Networking for OpenShift Container Platform nodes uses DHCP by default to gather all necessary configuration settings. To set up static IP addresses or configure special settings, such as bonding, you can do one of the following:

- Pass special kernel parameters when you boot the live installer.
- Use a machine config to copy networking files to the installed system.
- Configure networking from a live installer shell prompt, then copy those settings to the installed system so that they take effect when the installed system first boots.

To configure a PXE or iPXE installation, use one of the following options:

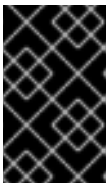
- See the "Advanced RHCOS installation reference" tables.
- Use a machine config to copy networking files to the installed system.

To configure an ISO installation, use the following procedure.

Procedure

1. Boot the ISO installer.
2. From the live system shell prompt, configure networking for the live system using available RHEL tools, such as **nmcli** or **nmtui**.
3. Run the **coreos-installer** command to install the system, adding the **--copy-network** option to copy networking configuration. For example:

```
$ sudo coreos-installer install --copy-network \
    --ignition-url=http://host/worker.ign /dev/sda
```



IMPORTANT

The **--copy-network** option only copies networking configuration found under **/etc/NetworkManager/system-connections**. In particular, it does not copy the system hostname.

4. Reboot into the installed system.

Additional resources

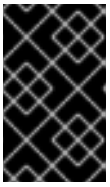
- See Getting started with nmcli and Getting started with nmtui in the RHEL 8 documentation for more information about the **nmcli** and **nmtui** tools.

23.1.11.3.2. Disk partitioning

The disk partitions are created on OpenShift Container Platform cluster nodes during the Red Hat Enterprise Linux CoreOS (RHCOS) installation. Each RHCOS node of a particular architecture uses the same partition layout, unless the default partitioning configuration is overridden. During the RHCOS installation, the size of the root file system is increased to use the remaining available space on the target device.

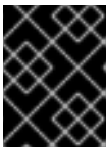
There are two cases where you might want to override the default partitioning when installing RHCOS on an OpenShift Container Platform cluster node:

- Creating separate partitions: For greenfield installations on an empty disk, you might want to add separate storage to a partition. This is officially supported for mounting **/var** or a subdirectory of **/var**, such as **/var/lib/etcd**, on a separate partition, but not both.



IMPORTANT

For disk sizes larger than 100GB, and especially disk sizes larger than 1TB, create a separate **/var** partition. See "Creating a separate **/var** partition" and this Red Hat Knowledgebase article for more information.



IMPORTANT

Kubernetes supports only two file system partitions. If you add more than one partition to the original configuration, Kubernetes cannot monitor all of them.

- Retaining existing partitions: For a brownfield installation where you are reinstalling OpenShift Container Platform on an existing node and want to retain data partitions installed from your previous operating system, there are both boot arguments and options to **coreos-installer** that allow you to retain existing data partitions.

WARNING

The use of custom partitions could result in those partitions not being monitored by OpenShift Container Platform or alerted on. If you are overriding the default partitioning, see Understanding OpenShift File System Monitoring (eviction conditions) for more information about how OpenShift Container Platform monitors your host file systems.

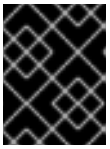
23.1.11.3.2.1. Creating a separate /var partition

In general, you should use the default disk partitioning that is created during the RHCOS installation. However, there are cases where you might want to create a separate partition for a directory that you expect to grow.

OpenShift Container Platform supports the addition of a single partition to attach storage to either the **/var** directory or a subdirectory of **/var**. For example:

- **/var/lib/containers**: Holds container-related content that can grow as more images and containers are added to a system.

- **/var/lib/etcd**: Holds data that you might want to keep separate for purposes such as performance optimization of etcd storage.
- **/var**: Holds data that you might want to keep separate for purposes such as auditing.



IMPORTANT

For disk sizes larger than 100GB, and especially larger than 1TB, create a separate **/var** partition.

Storing the contents of a **/var** directory separately makes it easier to grow storage for those areas as needed and reinstall OpenShift Container Platform at a later date and keep that data intact. With this method, you will not have to pull all your containers again, nor will you have to copy massive log files when you update systems.

The use of a separate partition for the **/var** directory or a subdirectory of **/var** also prevents data growth in the partitioned directory from filling up the root file system.

The following procedure sets up a separate **/var** partition by adding a machine config manifest that is wrapped into the Ignition config file for a node type during the preparation phase of an installation.

Procedure

1. On your installation host, change to the directory that contains the OpenShift Container Platform installation program and generate the Kubernetes manifests for the cluster:

```
$ openshift-install create manifests --dir <installation_directory>
```

2. Create a Butane config that configures the additional partition. For example, name the file **$HOME/clusterconfig/98-var-partition.bu**, change the disk device name to the name of the storage device on the **worker** systems, and set the storage size as appropriate. This example places the **/var** directory on a separate partition:

```
variant: openshift
version: 4.11.0
metadata:
  labels:
    machineconfiguration.openshift.io/role: worker
  name: 98-var-partition
storage:
  disks:
  - device: /dev/<device_name> 1
    partitions:
    - label: var
      start_mib: <partition_start_offset> 2
      size_mib: <partition_size> 3
  filesystems:
    - device: /dev/disk/by-partlabel/var
      path: /var
      format: xfs
      mount_options: [defaults, prjquota] 4
      with_mount_unit: true
```

1 The storage device name of the disk that you want to partition.

2 When adding a data partition to the boot disk, a minimum offset value of 25000 mebibytes is recommended. The root file system is automatically resized to fill all available space up

3 The size of the data partition in mebibytes.

4 The **prjquota** mount option must be enabled for filesystems used for container storage.

NOTE

When creating a separate /**var** partition, you cannot use different instance types for compute nodes, if the different instance types do not have the same device name.

3. Create a manifest from the Butane config and save it to the **clusterconfig/openshift** directory. For example, run the following command:

```
$ butane $HOME/clusterconfig/98-var-partition.bu -o $HOME/clusterconfig/openshift/98-var-partition.yaml
```

4. Create the Ignition config files:

```
$ openshift-install create ignition-configs --dir <installation_directory> 1
```

1 For **<installation_directory>**, specify the same installation directory.

Ignition config files are created for the bootstrap, control plane, and compute nodes in the installation directory:

```
.
├── auth
│   ├── kubeadmin-password
│   └── kubeconfig
├── bootstrap.ign
├── master.ign
├── metadata.json
└── worker.ign
```

The files in the **<installation_directory>/manifest** and **<installation_directory>/openshift** directories are wrapped into the Ignition config files, including the file that contains the **98-var-partition** custom **MachineConfig** object.

Next steps

- You can apply the custom disk partitioning by referencing the Ignition config files during the RHCOS installations.

23.1.11.3.2.2. Retaining existing partitions

For an ISO installation, you can add options to the **coreos-installer** command that cause the installer to maintain one or more existing partitions. For a PXE installation, you can add **coreos.inst.*** options to the **APPEND** parameter to preserve partitions.

Saved partitions might be data partitions from an existing OpenShift Container Platform system. You can identify the disk partitions you want to keep either by partition label or by number.

NOTE

If you save existing partitions, and those partitions do not leave enough space for RHCOS, the installation will fail without damaging the saved partitions.

Retaining existing partitions during an ISO installation

This example preserves any partition in which the partition label begins with **data** (**data***):

```
# coreos-installer install --ignition-url http://10.0.2.2:8080/user.ign \
      --save-partlabel 'data*' /dev/sda
```

The following example illustrates running the **coreos-installer** in a way that preserves the sixth (6) partition on the disk:

```
# coreos-installer install --ignition-url http://10.0.2.2:8080/user.ign \
      --save-partindex 6 /dev/sda
```

This example preserves partitions 5 and higher:

```
# coreos-installer install --ignition-url http://10.0.2.2:8080/user.ign
      --save-partindex 5- /dev/sda
```

In the previous examples where partition saving is used, **coreos-installer** recreates the partition immediately.

Retaining existing partitions during a PXE installation

This **APPEND** option preserves any partition in which the partition label begins with 'data' ('data*'):

```
coreos.inst.save_partlabel=data*
```

This **APPEND** option preserves partitions 5 and higher:

```
coreos.inst.save_partindex=5-
```

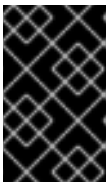
This **APPEND** option preserves partition 6:

```
coreos.inst.save_partindex=6
```

23.1.11.3.3. Identifying Ignition configs

When doing an RHCOS manual installation, there are two types of Ignition configs that you can provide, with different reasons for providing each one:

- **Permanent install Ignition config**: Every manual RHCOS installation needs to pass one of the Ignition config files generated by **openshift-installer**, such as **bootstrap.ign**, **master.ign** and **worker.ign**, to carry out the installation.



IMPORTANT

It is not recommended to modify these Ignition config files directly. You can update the manifest files that are wrapped into the Ignition config files, as outlined in examples in the preceding sections.

For PXE installations, you pass the Ignition configs on the **APPEND** line using the **coreos.inst.ignition_url=** option. For ISO installations, after the ISO boots to the shell prompt, you identify the Ignition config on the **coreos-installer** command line with the **--ignition-url=** option. In both cases, only HTTP and HTTPS protocols are supported.

- **Live install Ignition config**: This type can be created by using the **coreos-installer customize** subcommand and its various options. With this method, the Ignition config passes to the live install medium, runs immediately upon booting, and performs setup tasks before or after the RHCOS system installs to disk. This method should only be used for performing tasks that must be done once and not applied again later, such as with advanced partitioning that cannot be done using a machine config.
  For PXE or ISO boots, you can create the Ignition config and **APPEND** the **ignition.config.url=** option to identify the location of the Ignition config. You also need to append **ignition.firstboot ignition.platform.id=metal** or the **ignition.config.url** option will be ignored.

23.1.11.3.4. Advanced RHCOS installation reference

This section illustrates the networking configuration and other advanced options that allow you to modify the Red Hat Enterprise Linux CoreOS (RHCOS) manual installation process. The following tables describe the kernel arguments and command-line options you can use with the RHCOS live installer and the **coreos-installer** command.

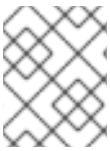
23.1.11.3.4.1. Networking and bonding options for ISO installations

If you install RHCOS from an ISO image, you can add kernel arguments manually when you boot the image to configure networking for a node. If no networking arguments are specified, DHCP is activated in the initramfs when RHCOS detects that networking is required to fetch the Ignition config file.

IMPORTANT

When adding networking arguments manually, you must also add the **rd.neednet=1** kernel argument to bring the network up in the initramfs.

The following information provides examples for configuring networking and bonding on your RHCOS nodes for ISO installations. The examples describe how to use the **ip=**, **nameserver=**, and **bond=** kernel arguments.



NOTE

Ordering is important when adding the kernel arguments: **ip=**, **nameserver=**, and then **bond=**.

The networking options are passed to the **dracut** tool during system boot. For more information about the networking options supported by **dracut**, see the **dracut.cmdline** manual page.

The following examples are the networking options for ISO installation.

Configuring DHCP or static IP addresses

To configure an IP address, either use DHCP (**ip=dhcp**) or set an individual static IP address (**ip=<host_ip>**). If setting a static IP, you must then identify the DNS server IP address (**nameserver=<dns_ip>**) on each node. The following example sets:

- The node's IP address to **10.10.10.2**
- The gateway address to **10.10.10.254**
- The netmask to **255.255.255.0**
- The hostname to **core0.example.com**
- The DNS server address to **4.4.4.41**
- The auto-configuration value to **none**. No auto-configuration is required when IP networking is configured statically.

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp1s0:none
nameserver=4.4.4.41
```

NOTE

When you use DHCP to configure IP addressing for the RHCOS machines, the machines also obtain the DNS server information through DHCP. For DHCP-based deployments, you can define the DNS server address that is used by the RHCOS nodes through your DHCP server configuration.

Configuring an IP address without a static hostname
You can configure an IP address without assigning a static hostname. If a static hostname is not set by the user, it will be picked up and automatically set by a reverse DNS lookup. To configure an IP address without a static hostname refer to the following example:

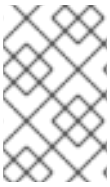
- The node's IP address to **10.10.10.2**
- The gateway address to **10.10.10.254**
- The netmask to **255.255.255.0**
- The DNS server address to **4.4.4.41**
- The auto-configuration value to **none**. No auto-configuration is required when IP networking is configured statically.

```
ip=10.10.10.2::10.10.10.254:255.255.255.0::enp1s0:none
nameserver=4.4.4.41
```

Specifying multiple network interfaces
You can specify multiple network interfaces by setting multiple **ip=** entries.

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp1s0:none
ip=10.10.10.3::10.10.10.254:255.255.255.0:core0.example.com:enp2s0:none
```

Configuring default gateway and route
Optional: You can configure routes to additional networks by setting an **rd.route=** value.



NOTE

When you configure one or multiple networks, one default gateway is required. If the additional network gateway is different from the primary network gateway, the default gateway must be the primary network gateway.

- Run the following command to configure the default gateway:

```
ip=::10.10.10.254::::
```

- Enter the following command to configure the route for the additional network:

```
rd.route=20.20.20.0/24:20.20.20.254:enp2s0
```

Disabling DHCP on a single interface
You can disable DHCP on a single interface, such as when there are two or more network interfaces and only one interface is being used. In the example, the **enp1s0** interface has a static networking configuration and DHCP is disabled for **enp2s0**, which is not used:

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp1s0:none
ip=::::core0.example.com:enp2s0:none
```

Combining DHCP and static IP configurations
You can combine DHCP and static IP configurations on systems with multiple network interfaces, for example:

```
ip=enp1s0:dhcp
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp2s0:none
```

Configuring VLANs on individual interfaces
Optional: You can configure VLANs on individual interfaces by using the **vlan=** parameter.

- To configure a VLAN on a network interface and use a static IP address, run the following command:

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp2s0.100:none
vlan=enp2s0.100:enp2s0
```

- To configure a VLAN on a network interface and to use DHCP, run the following command:

```
ip=enp2s0.100:dhcp
vlan=enp2s0.100:enp2s0
```

Providing multiple DNS servers
You can provide multiple DNS servers by adding a **nameserver=** entry for each server, for example:

```
nameserver=1.1.1.1
nameserver=8.8.8.8
```

Bonding multiple network interfaces to a single interface
Optional: You can bond multiple network interfaces to a single interface by using the **bond=** option. Refer to the following examples:

- The syntax for configuring a bonded interface is: **bond=name[:network_interfaces][:options]**
name is the bonding device name (**bond0**), *network_interfaces* represents a comma-separated list of physical (ethernet) interfaces (**em1,em2**), and *options* is a comma-separated list of bonding options. Enter **modinfo bonding** to see available options.

- When you create a bonded interface using **bond=**, you must specify how the IP address is assigned and other information for the bonded interface.

- To configure the bonded interface to use DHCP, set the bond's IP address to **dhcp**. For example:

```
bond=bond0:em1,em2:mode=active-backup
ip=bond0:dhcp
```

- To configure the bonded interface to use a static IP address, enter the specific IP address you want and related information. For example:

```
bond=bond0:em1,em2:mode=active-backup
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:bond0:none
```

Bonding multiple network interfaces to a single interface
Optional: You can configure VLANs on bonded interfaces by using the **vlan=** parameter and to use DHCP, for example:

```
ip=bond0.100:dhcp
bond=bond0:em1,em2:mode=active-backup
vlan=bond0.100:bond0
```

Use the following example to configure the bonded interface with a VLAN and to use a static IP address:

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:bond0.100:none
bond=bond0:em1,em2:mode=active-backup
vlan=bond0.100:bond0
```

Using network teaming
Optional: You can use a network teaming as an alternative to bonding by using the **team=** parameter:

- The syntax for configuring a team interface is: **team=name[:network_interfaces]**
name is the team device name (**team0**) and *network_interfaces* represents a comma-separated list of physical (ethernet) interfaces (**em1, em2**).

NOTE

Teaming is planned to be deprecated when RHCOS switches to an upcoming version of RHEL. For more information, see this Red Hat Knowledgebase Article .

Use the following example to configure a network team:

```
team=team0:em1,em2
ip=team0:dhcp
```

23.1.11.3.4.2. **coreos-installer** options for ISO and PXE installations

You can install RHCOS by running **coreos-installer install <options> <device>** at the command prompt, after booting into the RHCOS live environment from an ISO image.

The following table shows the subcommands, options, and arguments you can pass to the **coreos-installer** command.

Table 23.9. coreos-installer subcommands, command-line options, and arguments

coreos-installer install subcommand	
Subcommand	*Description*
$ coreos-installer install <options> <device>	Embed an Ignition config in an ISO image.
coreos-installer install subcommand options	
Option	*Description*
-u, **--image-url <url>**	Specify the image URL manually.
-f, **--image-file <path>**	Specify a local image file manually. Used for debugging.
-i, --ignition-file <path>	Embed an Ignition config from a file.
-I, **--ignition-url <URL>**	Embed an Ignition config from a URL.
--ignition-hash <digest>	Digest **type-value** of the Ignition config.
-p, **--platform <name>**	Override the Ignition platform ID for the installed system.
--append-karg <arg>…	Append a default kernel argument to the installed system.
--delete-karg <arg>…	Delete a default kernel argument from the installed system.
-n, **--copy-network**	Copy the network configuration from the install environment.  IMPORTANT The **--copy-network** option only copies networking configuration found under **/etc/NetworkManager/system-connections**. In particular, it does not copy the system hostname.

--network-dir <path>	For use with **-n**. Default is **/etc/NetworkManager/system-connections/**.
--save-partlabel <lx>..	Save partitions with this label glob.
--save-partindex <id>…	Save partitions with this number or range.
--insecure	Skip RHCOS image signature verification.
--insecure-ignition	Allow Ignition URL without HTTPS or hash.
--architecture <name>	Target CPU architecture. Valid values are **x86_64** and **aarch64**.
--preserve-on-error	Do not clear partition table on error.
-h, **--help**	Print help information.
coreos-installer install subcommand argument	
Argument	*Description*
<device>	The destination device.
coreos-installer ISO subcommands	
Subcommand	*Description*
$ coreos-installer iso customize <options> <ISO_image>	Customize a RHCOS live ISO image.
coreos-installer iso reset <options> <ISO_image>	Restore a RHCOS live ISO image to default settings.
coreos-installer iso ignition remove <options> <ISO_image>	Remove the embedded Ignition config from an ISO image.
coreos-installer ISO customize subcommand options	
Option	*Description*
--dest-ignition <path>	Merge the specified Ignition config file into a new configuration fragment for the destination system.
--dest-device <path>	Install and overwrite the specified destination device.

--dest-karg-append <arg>	Add a kernel argument to each boot of the destination system.
--dest-karg-delete <arg>	Delete a kernel argument from each boot of the destination system.
--network-keyfile <path>	Configure networking by using the specified NetworkManager keyfile for live and destination systems.
--ignition-ca <path>	Specify an additional TLS certificate authority to be trusted by Ignition.
--pre-install <path>	Run the specified script before installation.
--post-install <path>	Run the specified script after installation.
--installer-config <path>	Apply the specified installer configuration file.
--live-ignition <path>	Merge the specified Ignition config file into a new configuration fragment for the live environment.
--live-karg-append <arg>	Add a kernel argument to each boot of the live environment.
--live-karg-delete <arg>	Delete a kernel argument from each boot of the live environment.
--live-karg-replace <k=o=n>	Replace a kernel argument in each boot of the live environment, in the form **key=old=new**.
-f, **--force**	Overwrite an existing Ignition config.
-o, **--output <path>**	Write the ISO to a new output file.
-h, **--help**	Print help information.
coreos-installer PXE subcommands	
Subcommand	*Description*
Note that not all of these options are accepted by all subcommands.	
coreos-installer pxe customize <options> <path>	Customize a RHCOS live PXE boot config.
coreos-installer pxe ignition wrap <options>	Wrap an Ignition config in an image.

coreos-installer pxe ignition unwrap <options> <image_name>	Show the wrapped Ignition config in an image.
coreos-installer PXE customize subcommand options	
Option	*Description*
Note that not all of these options are accepted by all subcommands.	
--dest-ignition <path>	Merge the specified Ignition config file into a new configuration fragment for the destination system.
--dest-device <path>	Install and overwrite the specified destination device.
--network-keyfile <path>	Configure networking by using the specified NetworkManager keyfile for live and destination systems.
--ignition-ca <path>	Specify an additional TLS certificate authority to be trusted by Ignition.
--pre-install <path>	Run the specified script before installation.
post-install <path>	Run the specified script after installation.
--installer-config <path>	Apply the specified installer configuration file.
--live-ignition <path>	Merge the specified Ignition config file into a new configuration fragment for the live environment.
-o, --output <path>	Write the initramfs to a new output file. NOTE This option is required for PXE environments.
-h, --help	Print help information.

23.1.11.3.4.3. **coreos.inst** boot options for ISO or PXE installations

You can automatically invoke **coreos-installer** options at boot time by passing **coreos.inst** boot arguments to the RHCOS live installer. These are provided in addition to the standard boot arguments.

- For ISO installations, the **coreos.inst** options can be added by interrupting the automatic boot at the bootloader menu. You can interrupt the automatic boot by pressing **TAB** while the **RHEL CoreOS (Live)** menu option is highlighted.

- For PXE or iPXE installations, the **coreos.inst** options must be added to the **APPEND** line before the RHCOS live installer is booted.

The following table shows the RHCOS live installer **coreos.inst** boot options for ISO and PXE installations.

Table 23.10. coreos.inst boot options

Argument	Description
coreos.inst.install_dev	Required. The block device on the system to install to. It is recommended to use the full path, such as **/dev/sda**, although **sda** is allowed.
coreos.inst.ignition_url	Optional: The URL of the Ignition config to embed into the installed system. If no URL is specified, no Ignition config is embedded. Only HTTP and HTTPS protocols are supported.
coreos.inst.save_partlabel	Optional: Comma-separated labels of partitions to preserve during the install. Glob-style wildcards are permitted. The specified partitions do not need to exist.
coreos.inst.save_partindex	Optional: Comma-separated indexes of partitions to preserve during the install. Ranges **m-n** are permitted, and either **m** or **n** can be omitted. The specified partitions do not need to exist.
coreos.inst.insecure	Optional: Permits the OS image that is specified by **coreos.inst.image_url** to be unsigned.
coreos.inst.image_url	Optional: Download and install the specified RHCOS image. • This argument should not be used in production environments and is intended for debugging purposes only. • While this argument can be used to install a version of RHCOS that does not match the live media, it is recommended that you instead use the media that matches the version you want to install. • If you are using **coreos.inst.image_url**, you must also use **coreos.inst.insecure**. This is because the bare-metal media are not GPG-signed for OpenShift Container Platform. • Only HTTP and HTTPS protocols are supported.

Argument	Description
coreos.inst.skip_reboot	Optional: The system will not reboot after installing. After the install finishes, you will receive a prompt that allows you to inspect what is happening during installation. This argument should not be used in production environments and is intended for debugging purposes only.
coreos.inst.platform_id	Optional: The Ignition platform ID of the platform the RHCOS image is being installed on. Default is **metal**. This option determines whether or not to request an Ignition config from the cloud provider, such as VMware. For example: **coreos.inst.platform_id=vmware**.
ignition.config.url	Optional: The URL of the Ignition config for the live boot. For example, this can be used to customize how **coreos-installer** is invoked, or to run code before or after the installation. This is different from **coreos.inst.ignition_url**, which is the Ignition config for the installed system.

23.1.11.4. Updating the bootloader using bootupd

To update the bootloader by using **bootupd**, you must either install **bootupd** on RHCOS machines manually or provide a machine config with the enabled **systemd** unit. Unlike **grubby** or other bootloader tools, **bootupd** does not manage kernel space configuration such as passing kernel arguments.

After you have installed **bootupd**, you can manage it remotely from the OpenShift Container Platform cluster.

NOTE

It is recommended that you use **bootupd** only on bare metal or virtualized hypervisor installations, such as for protection against the BootHole vulnerability.

Manual install method

You can manually install **bootupd** by using the **bootctl** command-line tool.

1. Inspect the system status:

```
# bootupctl status
```

Example output for x86_64

```
Component EFI
  Installed: grub2-efi-x64-1:2.04-31.fc33.x86_64,shim-x64-15-8.x86_64
  Update: At latest version
```

Example output for aarch64

```
Component EFI
  Installed: grub2-efi-aa64-1:2.02-99.el8_4.1.aarch64,shim-aa64-15.4-2.el8_1.aarch64
  Update: At latest version
```

2. RHCOS images created without **bootupd** installed on them require an explicit adoption phase. If the system status is **Adoptable**, perform the adoption:

```
# bootupctl adopt-and-update
```

Example output

```
Updated: grub2-efi-x64-1:2.04-31.fc33.x86_64,shim-x64-15-8.x86_64
```

3. If an update is available, apply the update so that the changes take effect on the next reboot:

```
# bootupctl update
```

Example output

```
Updated: grub2-efi-x64-1:2.04-31.fc33.x86_64,shim-x64-15-8.x86_64
```

Machine config method

Another way to enable **bootupd** is by providing a machine config.

- Provide a machine config file with the enabled **systemd** unit, as shown in the following example:

Example output

```
variant: rhcos
version: 1.1.0
systemd:
  units:
    - name: custom-bootupd-auto.service
      enabled: true
      contents: |
        [Unit]
        Description=Bootupd automatic update

        [Service]
        ExecStart=/usr/bin/bootupctl update
        RemainAfterExit=yes

        [Install]
        WantedBy=multi-user.target
```

23.1.12. Waiting for the bootstrap process to complete

The OpenShift Container Platform bootstrap process begins after the cluster nodes first boot into the persistent RHCOS environment that has been installed to disk. The configuration information provided

through the Ignition config files is used to initialize the bootstrap process and install OpenShift Container Platform on the machines. You must wait for the bootstrap process to complete.

Prerequisites

- You have created the Ignition config files for your cluster.
- You have configured suitable network, DNS and load balancing infrastructure.
- You have obtained the installation program and generated the Ignition config files for your cluster.
- You installed RHCOS on your cluster machines and provided the Ignition config files that the OpenShift Container Platform installation program generated.
- Your machines have direct internet access or have an HTTP or HTTPS proxy available.

Procedure

1. Monitor the bootstrap process:

```
$ ./openshift-install --dir <installation_directory> wait-for bootstrap-complete \ 1
    --log-level=info 2
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

Example output

```
INFO Waiting up to 30m0s for the Kubernetes API at https://api.test.example.com:6443...
INFO API v1.24.0 up
INFO Waiting up to 30m0s for bootstrapping to complete...
INFO It is now safe to remove the bootstrap resources
```

The command succeeds when the Kubernetes API server signals that it has been bootstrapped on the control plane machines.

2. After the bootstrap process is complete, remove the bootstrap machine from the load balancer.

IMPORTANT

You must remove the bootstrap machine from the load balancer at this point. You can also remove or reformat the bootstrap machine itself.

23.1.13. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

Example output

```
system:admin
```

23.1.14. Approving the certificate signing requests for your machines

When you add machines to a cluster, two pending certificate signing requests (CSRs) are generated for each machine that you added. You must confirm that these CSRs are approved or, if necessary, approve them yourself. The client requests must be approved first, followed by the server requests.

Prerequisites

- You added machines to your cluster.

Procedure

1. Confirm that the cluster recognizes the machines:

```
$ oc get nodes
```

Example output

```
NAME      STATUS    ROLES   AGE  VERSION
master-0  Ready     master  63m  v1.24.0
master-1  Ready     master  63m  v1.24.0
master-2  Ready     master  64m  v1.24.0
```

The output lists all of the machines that you created.

NOTE

The preceding output might not include the compute nodes, also known as worker nodes, until some CSRs are approved.

2. Review the pending CSRs and ensure that you see the client requests with the **Pending** or **Approved** status for each machine that you added to the cluster:

```
$ oc get csr
```

Example output

```
NAME        AGE    REQUESTOR                                                   CONDITION
csr-8b2br   15m    system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper   Pending
csr-8vnps   15m    system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper   Pending
...
```

In this example, two machines are joining the cluster. You might see more approved CSRs in the list.

3. If the CSRs were not approved, after all of the pending CSRs for the machines you added are in **Pending** status, approve the CSRs for your cluster machines:

NOTE

Because the CSRs rotate automatically, approve your CSRs within an hour of adding the machines to the cluster. If you do not approve them within an hour, the certificates will rotate, and more than two certificates will be present for each node. You must approve all of these certificates. After the client CSR is approved, the Kubelet creates a secondary CSR for the serving certificate, which requires manual approval. Then, subsequent serving certificate renewal requests are automatically approved by the **machine-approver** if the Kubelet requests a new certificate with identical parameters.

NOTE

For clusters running on platforms that are not machine API enabled, such as bare metal and other user-provisioned infrastructure, you must implement a method of automatically approving the kubelet serving certificate requests (CSRs). If a request is not approved, then the **oc exec**, **oc rsh**, and **oc logs** commands cannot succeed, because a serving certificate is required when the API server connects to the kubelet. Any operation that contacts the Kubelet endpoint requires this certificate approval to be in place. The method must watch for new CSRs, confirm that the CSR was submitted by the **node-bootstrapper** service account in the **system:node** or **system:admin** groups, and confirm the identity of the node.

- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

1 **<csr_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{{"\n"}}
{{end}}{{end}}' | xargs --no-run-if-empty oc adm certificate approve
```

NOTE

Some Operators might not become available until some CSRs are approved.

4. Now that your client requests are approved, you must review the server requests for each machine that you added to the cluster:

```
$ oc get csr
```

Example output

```
NAME        AGE     REQUESTOR                                                   CONDITION
csr-bfd72   5m26s   system:node:ip-10-0-50-126.us-east-2.compute.internal
Pending
csr-c57lv   5m26s   system:node:ip-10-0-95-157.us-east-2.compute.internal
Pending
...
```

5. If the remaining CSRs are not approved, and are in the **Pending** status, approve the CSRs for your cluster machines:

- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

1 **<csr_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{{"\n"}}
{{end}}{{end}}' | xargs oc adm certificate approve
```

6. After all client and server CSRs have been approved, the machines have the **Ready** status. Verify this by running the following command:

```
$ oc get nodes
```

Example output

```
NAME      STATUS    ROLES   AGE  VERSION
master-0  Ready     master  73m  v1.24.0
master-1  Ready     master  73m  v1.24.0
```

```
master-2  Ready    master  74m  v1.24.0
worker-0  Ready    worker  11m  v1.24.0
worker-1  Ready    worker  11m  v1.24.0
```

NOTE

It can take a few minutes after approval of the server CSRs for the machines to transition to the **Ready** status.

Additional information

- For more information on CSRs, see Certificate Signing Requests.

23.1.15. Initial Operator configuration

After the control plane initializes, you must immediately configure some Operators so that they all become available.

Prerequisites

- Your control plane has initialized.

Procedure

1. Watch the cluster components come online:

```
$ watch -n5 oc get clusteroperators
```

Example output

```
NAME                                       VERSION   AVAILABLE   PROGRESSING   DEGRADED
SINCE
authentication                             4.11.0    True        False         False      19m
baremetal                                  4.11.0    True        False         False      37m
cloud-credential                           4.11.0    True        False         False      40m
cluster-autoscaler                         4.11.0    True        False         False      37m
config-operator                            4.11.0    True        False         False      38m
console                                    4.11.0    True        False         False      26m
csi-snapshot-controller                    4.11.0    True        False         False      37m
dns                                        4.11.0    True        False         False      37m
etcd                                       4.11.0    True        False         False      36m
image-registry                             4.11.0    True        False         False      31m
ingress                                    4.11.0    True        False         False      30m
insights                                   4.11.0    True        False         False      31m
kube-apiserver                             4.11.0    True        False         False      26m
kube-controller-manager                    4.11.0    True        False         False      36m
kube-scheduler                             4.11.0    True        False         False      36m
kube-storage-version-migrator              4.11.0    True        False         False      37m
machine-api                                4.11.0    True        False         False      29m
machine-approver                           4.11.0    True        False         False      37m
machine-config                             4.11.0    True        False         False      36m
marketplace                                4.11.0    True        False         False      37m
monitoring                                 4.11.0    True        False         False      29m
network                                    4.11.0    True        False         False      38m
```

```
node-tuning                                4.11.0    True        False         False      37m
openshift-apiserver                        4.11.0    True        False         False      32m
openshift-controller-manager               4.11.0    True        False         False      30m
openshift-samples                          4.11.0    True        False         False      32m
operator-lifecycle-manager                 4.11.0    True        False         False      37m
operator-lifecycle-manager-catalog         4.11.0    True        False         False      37m
operator-lifecycle-manager-packageserver   4.11.0    True        False         False      32m
service-ca                                 4.11.0    True        False         False      38m
storage                                    4.11.0    True        False         False      37m
```

2. Configure the Operators that are not available.

23.1.15.1. Disabling the default OperatorHub sources

Operator catalogs that source content provided by Red Hat and community projects are configured for OperatorHub by default during an OpenShift Container Platform installation. In a restricted network environment, you must disable the default catalogs as a cluster administrator.

Procedure

- Disable the sources for the default catalogs by adding **disableAllDefaultSources: true** to the **OperatorHub** object:

```
$ oc patch OperatorHub cluster --type json \
    -p '[{"op": "add", "path": "/spec/disableAllDefaultSources", "value": true}]'
```

TIP

Alternatively, you can use the web console to manage catalog sources. From the **Administration → Cluster Settings → Configuration → OperatorHub** page, click the **Sources** tab, where you can create, update, delete, disable, and enable individual sources.

23.1.15.2. Image registry removed during installation

On platforms that do not provide shareable object storage, the OpenShift Image Registry Operator bootstraps itself as **Removed**. This allows **openshift-installer** to complete installations on these platform types.

After installation, you must edit the Image Registry Operator configuration to switch the **managementState** from **Removed** to **Managed**.

23.1.15.3. Image registry storage configuration

The Image Registry Operator is not initially available for platforms that do not provide default storage. After installation, you must configure your registry to use storage so that the Registry Operator is made available.

Instructions are shown for configuring a persistent volume, which is required for production clusters. Where applicable, instructions are shown for configuring an empty directory as the storage location, which is available for only non-production clusters.

Additional instructions are provided for allowing the image registry to use block storage types by using the **Recreate** rollout strategy during upgrades.

23.1.15.3.1. Configuring registry storage for bare metal and other manual installations

As a cluster administrator, following installation you must configure your registry to use storage.

Prerequisites

- You have access to the cluster as a user with the **cluster-admin** role.
- You have a cluster that uses manually-provisioned Red Hat Enterprise Linux CoreOS (RHCOS) nodes, such as bare metal.
- You have provisioned persistent storage for your cluster, such as Red Hat OpenShift Data Foundation.

IMPORTANT

OpenShift Container Platform supports **ReadWriteOnce** access for image registry storage when you have only one replica. **ReadWriteOnce** access also requires that the registry uses the **Recreate** rollout strategy. To deploy an image registry that supports high availability with two or more replicas, **ReadWriteMany** access is required.

- Must have 100Gi capacity.

Procedure

1. To configure your registry to use storage, change the **spec.storage.pvc** in the **configs.imageregistry/cluster** resource.

NOTE

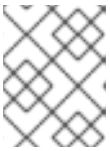
When you use shared storage, review your security settings to prevent outside access.

2. Verify that you do not have a registry pod:

```
$ oc get pod -n openshift-image-registry -l docker-registry=default
```

Example output

```
No resourses found in openshift-image-registry namespace
```



NOTE

If you do have a registry pod in your output, you do not need to continue with this procedure.

3. Check the registry configuration:

```
$ oc edit configs.imageregistry.operator.openshift.io
```

Example output

```
storage:
  pvc:
    claim:
```

Leave the **claim** field blank to allow the automatic creation of an **image-registry-storage** PVC.

4. Check the **clusteroperator** status:

```
$ oc get clusteroperator image-registry
```

Example output

```
NAME             VERSION       AVAILABLE   PROGRESSING   DEGRADED   SINCE
MESSAGE
image-registry   4.11          True        False         False      6h50m
```

5. Ensure that your registry is set to managed to enable building and pushing of images.

- Run:

```
$ oc edit configs.imageregistry/cluster
```

Then, change the line

```
managementState: Removed
```

to

```
managementState: Managed
```

23.1.15.3.2. Configuring storage for the image registry in non-production clusters

You must configure storage for the Image Registry Operator. For non-production clusters, you can set the image registry to an empty directory. If you do so, all images are lost if you restart the registry.

Procedure

- To set the image registry storage to an empty directory:

```
$ oc patch configs.imageregistry.operator.openshift.io cluster --type merge --patch '{"spec":
{"storage":{"emptyDir":{}}}}'
```

WARNING

Configure this option for only non-production clusters.

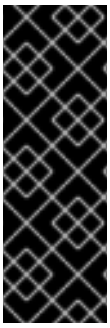
If you run this command before the Image Registry Operator initializes its components, the **oc patch** command fails with the following error:

```
Error from server (NotFound): configs.imageregistry.operator.openshift.io "cluster" not found
```

Wait a few minutes and run the command again.

23.1.15.3.3. Configuring block registry storage for bare metal

To allow the image registry to use block storage types during upgrades as a cluster administrator, you can use the **Recreate** rollout strategy.



IMPORTANT

Block storage volumes, or block persistent volumes, are supported but not recommended for use with the image registry on production clusters. An installation where the registry is configured on block storage is not highly available because the registry cannot have more than one replica.

If you choose to use a block storage volume with the image registry, you must use a filesystem persistent volume claim (PVC).

Procedure

1. Enter the following command to set the image registry storage as a block storage type, patch the registry so that it uses the **Recreate** rollout strategy, and runs with only one (**1**) replica:

```
$ oc patch config.imageregistry.operator.openshift.io/cluster --type=merge -p '{"spec":
{"rolloutStrategy":"Recreate","replicas":1}}'
```

2. Provision the PV for the block storage device, and create a PVC for that volume. The requested block volume uses the ReadWriteOnce (RWO) access mode.

   a. Create a **pvc.yaml** file with the following contents to define a VMware vSphere **PersistentVolumeClaim** object:

```
kind: PersistentVolumeClaim
apiVersion: v1
metadata:
  name: image-registry-storage 1
  namespace: openshift-image-registry 2
spec:
  accessModes:
  - ReadWriteOnce 3
  resources:
    requests:
      storage: 100Gi 4
```

1. A unique name that represents the **PersistentVolumeClaim** object.
2. The namespace for the **PersistentVolumeClaim** object, which is **openshift-image-registry**.
3.

The access mode of the persistent volume claim. With **ReadWriteOnce**, the volume can be mounted with read and write permissions by a single node.

4 The size of the persistent volume claim.

b. Enter the following command to create the **PersistentVolumeClaim** object from the file:

```
$ oc create -f pvc.yaml -n openshift-image-registry
```

3. Enter the following command to edit the registry configuration so that it references the correct PVC:

```
$ oc edit config.imageregistry.operator.openshift.io -o yaml
```

Example output

```
storage:
  pvc:
    claim: 1
```

1 By creating a custom PVC, you can leave the **claim** field blank for the default automatic creation of an **image-registry-storage** PVC.

23.1.16. Completing installation on user-provisioned infrastructure

After you complete the Operator configuration, you can finish installing the cluster on infrastructure that you provide.

Prerequisites

- Your control plane has initialized.
- You have completed the initial Operator configuration.

Procedure

1. Confirm that all the cluster components are online with the following command:

```
$ watch -n5 oc get clusteroperators
```

Example output

```
NAME                                       VERSION   AVAILABLE   PROGRESSING   DEGRADED
SINCE
authentication                             4.11.0    True        False         False     19m
baremetal                                  4.11.0    True        False         False     37m
cloud-credential                           4.11.0    True        False         False     40m
cluster-autoscaler                         4.11.0    True        False         False     37m
config-operator                            4.11.0    True        False         False     38m
console                                    4.11.0    True        False         False     26m
csi-snapshot-controller                    4.11.0    True        False         False     37m
```

```
dns                                        4.11.0    True        False         False      37m
etcd                                       4.11.0    True        False         False      36m
image-registry                             4.11.0    True        False         False      31m
ingress                                    4.11.0    True        False         False      30m
insights                                   4.11.0    True        False         False      31m
kube-apiserver                             4.11.0    True        False         False      26m
kube-controller-manager                    4.11.0    True        False         False      36m
kube-scheduler                             4.11.0    True        False         False      36m
kube-storage-version-migrator              4.11.0    True        False         False      37m
machine-api                                4.11.0    True        False         False      29m
machine-approver                           4.11.0    True        False         False      37m
machine-config                             4.11.0    True        False         False      36m
marketplace                                4.11.0    True        False         False      37m
monitoring                                 4.11.0    True        False         False      29m
network                                    4.11.0    True        False         False      38m
node-tuning                                4.11.0    True        False         False      37m
openshift-apiserver                        4.11.0    True        False         False      32m
openshift-controller-manager               4.11.0    True        False         False      30m
openshift-samples                          4.11.0    True        False         False      32m
operator-lifecycle-manager                 4.11.0    True        False         False      37m
operator-lifecycle-manager-catalog         4.11.0    True        False         False      37m
operator-lifecycle-manager-packageserver   4.11.0    True        False         False      32m
service-ca                                 4.11.0    True        False         False      38m
storage                                    4.11.0    True        False         False      37m
```

Alternatively, the following command notifies you when all of the clusters are available. It also retrieves and displays credentials:

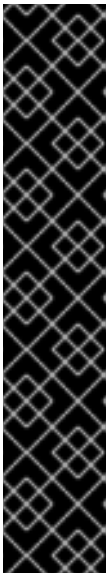
```
$ ./openshift-install --dir <installation_directory> wait-for install-complete 1
```

1 For **<installation_directory>**, specify the path to the directory that you stored the installation files in.

Example output

```
INFO Waiting up to 30m0s for the cluster to initialize...
```

The command succeeds when the Cluster Version Operator finishes deploying the OpenShift Container Platform cluster from Kubernetes API server.



IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

2. Confirm that the Kubernetes API server is communicating with the pods.

   a. To view a list of all pods, use the following command:

   ```
   $ oc get pods --all-namespaces
   ```

   Example output

   ```
   NAMESPACE                       NAME                                        READY   STATUS
   RESTARTS   AGE
   openshift-apiserver-operator    openshift-apiserver-operator-85cb746d55-zqhs8   1/1
   Running    1          9m
   openshift-apiserver             apiserver-67b9g                               1/1     Running     0
   3m
   openshift-apiserver             apiserver-ljcmx                               1/1     Running     0
   1m
   openshift-apiserver             apiserver-z25h4                               1/1     Running     0
   2m
   openshift-authentication-operator authentication-operator-69d5d8bf84-vh2n8        1/1
   Running    0          5m
   ...
   ```

   b. View the logs for a pod that is listed in the output of the previous command by using the following command:

   ```
   $ oc logs <pod_name> -n <namespace> 1
   ```

   1 Specify the pod name and namespace, as shown in the output of the previous command.

   If the pod logs display, the Kubernetes API server can communicate with the cluster machines.

3. For an installation with Fibre Channel Protocol (FCP), additional steps are required to enable multipathing. Do not enable multipathing during installation.
   See "Enabling multipathing with kernel arguments on RHCOS" in the *Post-installation machine configuration tasks* documentation for more information.

23.1.17. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.11, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to OpenShift Cluster Manager Hybrid Cloud Console.

After you confirm that your OpenShift Cluster Manager Hybrid Cloud Console inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, use subscription watch to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

Additional resources

- See About remote health monitoring for more information about the Telemetry service

23.1.18. Next steps

- Customize your cluster.
- If necessary, you can opt out of remote health reporting .
- Set up your registry and configure registry storage .

CHAPTER 24. INSTALLATION CONFIGURATION

24.1. CUSTOMIZING NODES

OpenShift Container Platform supports both cluster-wide and per-machine configuration via Ignition, which allows arbitrary partitioning and file content changes to the operating system. In general, if a configuration file is documented in Red Hat Enterprise Linux (RHEL), then modifying it via Ignition is supported.

There are two ways to deploy machine config changes:

- Creating machine configs that are included in manifest files to start up a cluster during **openshift-install**.
- Creating machine configs that are passed to running OpenShift Container Platform nodes via the Machine Config Operator.

Additionally, modifying the reference config, such as the Ignition config that is passed to **coreos-installer** when installing bare-metal nodes allows per-machine configuration. These changes are currently not visible to the Machine Config Operator.

The following sections describe features that you might want to configure on your nodes in this way.

24.1.1. Creating machine configs with Butane

Machine configs are used to configure control plane and worker machines by instructing machines how to create users and file systems, set up the network, install systemd units, and more.

Because modifying machine configs can be difficult, you can use Butane configs to create machine configs for you, thereby making node configuration much easier.

24.1.1.1. About Butane

Butane is a command-line utility that OpenShift Container Platform uses to provide convenient, short-hand syntax for writing machine configs, as well as for performing additional validation of machine configs. The format of the Butane config file that Butane accepts is defined in the OpenShift Butane config spec.

24.1.1.2. Installing Butane

You can install the Butane tool (**butane**) to create OpenShift Container Platform machine configs from a command-line interface. You can install **butane** on Linux, Windows, or macOS by downloading the corresponding binary file.

TIP

Butane releases are backwards-compatible with older releases and with the Fedora CoreOS Config Transpiler (FCCT).

Procedure

1. Navigate to the Butane image download page at https://mirror.openshift.com/pub/openshift-v4/clients/butane/.

2. Get the **butane** binary:

   a. For the newest version of Butane, save the latest **butane** image to your current directory:

   ```
   $ curl https://mirror.openshift.com/pub/openshift-v4/clients/butane/latest/butane --output butane
   ```

   b. Optional: For a specific type of architecture you are installing Butane on, such as aarch64 or ppc64le, indicate the appropriate URL. For example:

   ```
   $ curl https://mirror.openshift.com/pub/openshift-v4/clients/butane/latest/butane-aarch64 --output butane
   ```

3. Make the downloaded binary file executable:

   ```
   $ chmod +x butane
   ```

4. Move the **butane** binary file to a directory on your **PATH**.
   To check your **PATH**, open a terminal and execute the following command:

   ```
   $ echo $PATH
   ```

Verification steps

- You can now use the Butane tool by running the **butane** command:

  ```
  $ butane <butane_file>
  ```

24.1.1.3. Creating a MachineConfig object by using Butane

You can use Butane to produce a **MachineConfig** object so that you can configure worker or control plane nodes at installation time or via the Machine Config Operator.

Prerequisites

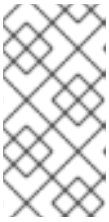
- You have installed the **butane** utility.

Procedure

1. Create a Butane config file. The following example creates a file named **99-worker-custom.bu** that configures the system console to show kernel debug messages and specifies custom settings for the chrony time service:

   ```
   variant: openshift
   version: 4.11.0
   metadata:
     name: 99-worker-custom
     labels:
       machineconfiguration.openshift.io/role: worker
   openshift:
     kernel_arguments:
       - loglevel=7
   storage:
   ```

```
files:
  - path: /etc/chrony.conf
    mode: 0644
    overwrite: true
    contents:
      inline: |
        pool 0.rhel.pool.ntp.org iburst
        driftfile /var/lib/chrony/drift
        makestep 1.0 3
        rtcsync
        logdir /var/log/chrony
```



NOTE

The **99-worker-custom.bu** file is set to create a machine config for worker nodes. To deploy on control plane nodes, change the role from **worker** to **master**. To do both, you could repeat the whole procedure using different file names for the two types of deployments.

2. Create a **MachineConfig** object by giving Butane the file that you created in the previous step:

```
$ butane 99-worker-custom.bu -o ./99-worker-custom.yaml
```

   A **MachineConfig** object YAML file is created for you to finish configuring your machines.

3. Save the Butane config in case you need to update the **MachineConfig** object in the future.

4. If the cluster is not running yet, generate manifest files and add the **MachineConfig** object YAML file to the **openshift** directory. If the cluster is already running, apply the file as follows:

```
$ oc create -f 99-worker-custom.yaml
```

Additional resources

- Adding kernel modules to nodes
- Encrypting and mirroring disks during installation

24.1.2. Adding day-1 kernel arguments

Although it is often preferable to modify kernel arguments as a day-2 activity, you might want to add kernel arguments to all master or worker nodes during initial cluster installation. Here are some reasons you might want to add kernel arguments during cluster installation so they take effect before the systems first boot up:

- You need to do some low-level network configuration before the systems start.
- You want to disable a feature, such as SELinux, so it has no impact on the systems when they first come up.

WARNING

Disabling SELinux on RHCOS in production is not supported. Once SELinux has been disabled on a node, it must be re-provisioned before re-inclusion in a production cluster.

To add kernel arguments to master or worker nodes, you can create a **MachineConfig** object and inject that object into the set of manifest files used by Ignition during cluster setup.

For a listing of arguments you can pass to a RHEL 8 kernel at boot time, see Kernel.org kernel parameters. It is best to only add kernel arguments with this procedure if they are needed to complete the initial OpenShift Container Platform installation.

Procedure

1. Change to the directory that contains the installation program and generate the Kubernetes manifests for the cluster:

```
$ ./openshift-install create manifests --dir <installation_directory>
```

2. Decide if you want to add kernel arguments to worker or control plane nodes.

3. In the **openshift** directory, create a file (for example, **99-openshift-machineconfig-master-kargs.yaml**) to define a **MachineConfig** object to add the kernel settings. This example adds a **loglevel=7** kernel argument to control plane nodes:

```
$ cat << EOF > 99-openshift-machineconfig-master-kargs.yaml
apiVersion: machineconfiguration.openshift.io/v1
kind: MachineConfig
metadata:
  labels:
    machineconfiguration.openshift.io/role: master
  name: 99-openshift-machineconfig-master-kargs
spec:
  kernelArguments:
    - loglevel=7
EOF
```

You can change **master** to **worker** to add kernel arguments to worker nodes instead. Create a separate YAML file to add to both master and worker nodes.

You can now continue on to create the cluster.

24.1.3. Adding kernel modules to nodes

For most common hardware, the Linux kernel includes the device driver modules needed to use that hardware when the computer starts up. For some hardware, however, modules are not available in Linux. Therefore, you must find a way to provide those modules to each host computer. This procedure describes how to do that for nodes in an OpenShift Container Platform cluster.

When a kernel module is first deployed by following these instructions, the module is made available for the current kernel. If a new kernel is installed, the kmods-via-containers software will rebuild and deploy the module so a compatible version of that module is available with the new kernel.

The way that this feature is able to keep the module up to date on each node is by:

- Adding a systemd service to each node that starts at boot time to detect if a new kernel has been installed and
- If a new kernel is detected, the service rebuilds the module and installs it to the kernel

For information on the software needed for this procedure, see the kmods-via-containers github site.

A few important issues to keep in mind:

- This procedure is Technology Preview.
- Software tools and examples are not yet available in official RPM form and can only be obtained for now from unofficial **github.com** sites noted in the procedure.
- Third-party kernel modules you might add through these procedures are not supported by Red Hat.
- In this procedure, the software needed to build your kernel modules is deployed in a RHEL 8 container. Keep in mind that modules are rebuilt automatically on each node when that node gets a new kernel. For that reason, each node needs access to a **yum** repository that contains the kernel and related packages needed to rebuild the module. That content is best provided with a valid RHEL subscription.

24.1.3.1. Building and testing the kernel module container

Before deploying kernel modules to your OpenShift Container Platform cluster, you can test the process on a separate RHEL system. Gather the kernel module's source code, the KVC framework, and the kmod-via-containers software. Then build and test the module. To do that on a RHEL 8 system, do the following:

Procedure

1. Register a RHEL 8 system:

```
# subscription-manager register
```

2. Attach a subscription to the RHEL 8 system:

```
# subscription-manager attach --auto
```

3. Install software that is required to build the software and container:

```
# yum install podman make git -y
```

4. Clone the **kmod-via-containers** repository:

   a. Create a folder for the repository:

```
$ mkdir kmods; cd kmods
```

b. Clone the repository:

```
$ git clone https://github.com/kmods-via-containers/kmods-via-containers
```

5. Install a KVC framework instance on your RHEL 8 build host to test the module. This adds a **kmods-via-container** systemd service and loads it:

a. Change to the **kmod-via-containers** directory:

```
$ cd kmods-via-containers/
```

b. Install the KVC framework instance:

```
$ sudo make install
```

c. Reload the systemd manager configuration:

```
$ sudo systemctl daemon-reload
```

6. Get the kernel module source code. The source code might be used to build a third-party module that you do not have control over, but is supplied by others. You will need content similar to the content shown in the **kvc-simple-kmod** example that can be cloned to your system as follows:

```
$ cd .. ; git clone https://github.com/kmods-via-containers/kvc-simple-kmod
```

7. Edit the configuration file, **simple-kmod.conf** file, in this example, and change the name of the Dockerfile to **Dockerfile.rhel**:

a. Change to the **kvc-simple-kmod** directory:

```
$ cd kvc-simple-kmod
```

b. Rename the Dockerfile:

```
$ cat simple-kmod.conf
```

Example Dockerfile

```
KMOD_CONTAINER_BUILD_CONTEXT="https://github.com/kmods-via-containers/kvc-simple-kmod.git"
KMOD_CONTAINER_BUILD_FILE=Dockerfile.rhel
KMOD_SOFTWARE_VERSION=dd1a7d4
KMOD_NAMES="simple-kmod simple-procfs-kmod"
```

8. Create an instance of **kmods-via-containers@.service** for your kernel module, **simple-kmod** in this example:

```
$ sudo make install
```

9. Enable the **kmods-via-containers@.service** instance:

```
$ sudo kmods-via-containers build simple-kmod $(uname -r)
```

10. Enable and start the systemd service:

```
$ sudo systemctl enable kmods-via-containers@simple-kmod.service --now
```

a. Review the service status:

```
$ sudo systemctl status kmods-via-containers@simple-kmod.service
```

Example output

```
● kmods-via-containers@simple-kmod.service - Kmods Via Containers - simple-kmod
  Loaded: loaded (/etc/systemd/system/kmods-via-containers@.service;
        enabled; vendor preset: disabled)
  Active: active (exited) since Sun 2020-01-12 23:49:49 EST; 5s ago...
```

11. To confirm that the kernel modules are loaded, use the **lsmod** command to list the modules:

```
$ lsmod | grep simple_
```

Example output

```
simple_procfs_kmod     16384  0
simple_kmod            16384  0
```

12. Optional. Use other methods to check that the **simple-kmod** example is working:

- Look for a "Hello world" message in the kernel ring buffer with **dmesg**:

```
$ dmesg | grep 'Hello world'
```

Example output

```
[ 6420.761332] Hello world from simple_kmod.
```

- Check the value of **simple-procfs-kmod** in **/proc**:

```
$ sudo cat /proc/simple-procfs-kmod
```

Example output

```
simple-procfs-kmod number = 0
```

- Run the **spkut** command to get more information from the module:

```
$ sudo spkut 44
```

Example output

```
KVC: wrapper simple-kmod for 4.18.0-147.3.1.el8_1.x86_64
Running userspace wrapper using the kernel module container...
+ podman run -i --rm --privileged
  simple-kmod-dd1a7d4:4.18.0-147.3.1.el8_1.x86_64 spkut 44
simple-procfs-kmod number = 0
simple-procfs-kmod number = 44
```

Going forward, when the system boots this service will check if a new kernel is running. If there is a new kernel, the service builds a new version of the kernel module and then loads it. If the module is already built, it will just load it.

24.1.3.2. Provisioning a kernel module to OpenShift Container Platform

Depending on whether or not you must have the kernel module in place when OpenShift Container Platform cluster first boots, you can set up the kernel modules to be deployed in one of two ways:

- **Provision kernel modules at cluster install time (day-1)** You can create the content as a **MachineConfig** object and provide it to **openshift-install** by including it with a set of manifest files.
- **Provision kernel modules via Machine Config Operator (day-2)** If you can wait until the cluster is up and running to add your kernel module, you can deploy the kernel module software via the Machine Config Operator (MCO).

In either case, each node needs to be able to get the kernel packages and related software packages at the time that a new kernel is detected. There are a few ways you can set up each node to be able to obtain that content.

- Provide RHEL entitlements to each node.
- Get RHEL entitlements from an existing RHEL host, from the **/etc/pki/entitlement** directory and copy them to the same location as the other files you provide when you build your Ignition config.
- Inside the Dockerfile, add pointers to a **yum** repository containing the kernel and other packages. This must include new kernel packages as they are needed to match newly installed kernels.

24.1.3.2.1. Provision kernel modules via a MachineConfig object

By packaging kernel module software with a **MachineConfig** object, you can deliver that software to worker or control plane nodes at installation time or via the Machine Config Operator.

Procedure

1. Register a RHEL 8 system:

   ```
   # subscription-manager register
   ```

2. Attach a subscription to the RHEL 8 system:

   ```
   # subscription-manager attach --auto
   ```

3. Install software needed to build the software:

```
# yum install podman make git -y
```

4. Create a directory to host the kernel module and tooling:

```
$ mkdir kmods; cd kmods
```

5. Get the **kmods-via-containers** software:

   a. Clone the **kmods-via-containers** repository:

```
$ git clone https://github.com/kmods-via-containers/kmods-via-containers
```

   b. Clone the **kvc-simple-kmod** repository:

```
$ git clone https://github.com/kmods-via-containers/kvc-simple-kmod
```

6. Get your module software. In this example, **kvc-simple-kmod** is used.

7. Create a fakeroot directory and populate it with files that you want to deliver via Ignition, using the repositories cloned earlier:

   a. Create the directory:

```
$ FAKEROOT=$(mktemp -d)
```

   b. Change to the **kmod-via-containers** directory:

```
$ cd kmods-via-containers
```

   c. Install the KVC framework instance:

```
$ make install DESTDIR=${FAKEROOT}/usr/local CONFDIR=${FAKEROOT}/etc/
```

   d. Change to the **kvc-simple-kmod** directory:

```
$ cd ../kvc-simple-kmod
```

   e. Create the instance:

```
$ make install DESTDIR=${FAKEROOT}/usr/local CONFDIR=${FAKEROOT}/etc/
```

8. Clone the fakeroot directory, replacing any symbolic links with copies of their targets, by running the following command:

```
$ cd .. && rm -rf kmod-tree && cp -Lpr ${FAKEROOT} kmod-tree
```

9. Create a Butane config file, **99-simple-kmod.bu**, that embeds the kernel module tree and enables the systemd service.

NOTE

See "Creating machine configs with Butane" for information about Butane.

```
variant: openshift
version: 4.11.0
metadata:
  name: 99-simple-kmod
  labels:
    machineconfiguration.openshift.io/role: worker (1)
storage:
  trees:
    - local: kmod-tree
systemd:
  units:
    - name: kmods-via-containers@simple-kmod.service
      enabled: true
```

(1) To deploy on control plane nodes, change **worker** to **master**. To deploy on both control plane and worker nodes, perform the remainder of these instructions once for each node type.

10. Use Butane to generate a machine config YAML file, **99-simple-kmod.yaml**, containing the files and configuration to be delivered:

```
$ butane 99-simple-kmod.bu --files-dir . -o 99-simple-kmod.yaml
```

11. If the cluster is not up yet, generate manifest files and add this file to the **openshift** directory. If the cluster is already running, apply the file as follows:

```
$ oc create -f 99-simple-kmod.yaml
```

Your nodes will start the **kmods-via-containers@simple-kmod.service** service and the kernel modules will be loaded.

12. To confirm that the kernel modules are loaded, you can log in to a node (using **oc debug node/<openshift-node>**, then **chroot /host**). To list the modules, use the **lsmod** command:

```
$ lsmod | grep simple_
```

Example output

```
simple_procfs_kmod     16384  0
simple_kmod            16384  0
```

24.1.4. Encrypting and mirroring disks during installation

During an OpenShift Container Platform installation, you can enable boot disk encryption and mirroring on the cluster nodes.

24.1.4.1. About disk encryption

You can enable encryption for the boot disks on the control plane and compute nodes at installation time. OpenShift Container Platform supports the Trusted Platform Module (TPM) v2 and Tang encryption modes.

- TPM v2: This is the preferred mode. TPM v2 stores passphrases in a secure cryptoprocessor contained within a server. You can use this mode to prevent the boot disk data on a cluster node from being decrypted if the disk is removed from the server.
- Tang: Tang and Clevis are server and client components that enable network-bound disk encryption (NBDE). You can bind the boot disk data on your cluster nodes to one or more Tang servers. This prevents the data from being decrypted unless the nodes are on a secure network where the Tang servers can be accessed. Clevis is an automated decryption framework that is used to implement the decryption on the client side.

IMPORTANT

The use of the Tang encryption mode to encrypt your disks is only supported for bare metal and vSphere installations on user-provisioned infrastructure.

NOTE

On previous versions of Red Hat Enterprise Linux CoreOS (RHCOS), disk encryption was configured by specifying **/etc/clevis.json** in the Ignition config. That file is not supported in clusters created with OpenShift Container Platform 4.7 or above, and disk encryption should be configured by using the following procedure.

When the TPM v2 or Tang encryption modes are enabled, the RHCOS boot disks are encrypted using the LUKS2 format.

This feature:

- Is available for installer-provisioned infrastructure and user-provisioned infrastructure deployments
- Is supported on Red Hat Enterprise Linux CoreOS (RHCOS) systems only
- Sets up disk encryption during the manifest installation phase so all data written to disk, from first boot forward, is encrypted
- Requires no user intervention for providing passphrases
- Uses AES-256-XTS encryption, or AES-256-CBC if FIPS mode is enabled

24.1.4.1.1. Configuring an encryption threshold

In OpenShift Container Platform, you can specify a requirement for more than one Tang server. You can also configure the TPM v2 and Tang encryption modes simultaneously, so that the boot disk data can be decrypted only if the TPM secure cryptoprocessor is present and the Tang servers can be accessed over a secure network.

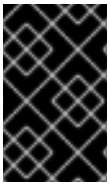
You can use the **threshold** attribute in your Butane configuration to define the minimum number of TPM v2 and Tang encryption conditions that must be met for decryption to occur. The threshold is met when the stated value is reached through any combination of the declared conditions. For example, the **threshold** value of **2** in the following configuration can be reached by accessing the two Tang servers, or by accessing the TPM secure cryptoprocessor and one of the Tang servers:

Example Butane configuration for disk encryption

```
variant: openshift
```

```
version: 4.11.0
metadata:
  name: worker-storage
  labels:
    machineconfiguration.openshift.io/role: worker
boot_device:
  layout: x86_64 1
  luks:
    tpm2: true 2
    tang: 3
      - url: http://tang1.example.com:7500
        thumbprint: jwGN5tRFK-kF6pIX89ssF3khxxX
      - url: http://tang2.example.com:7500
        thumbprint: VCJsvZFjBSIHSldw78rOrq7h2ZF
    threshold: 2 4
openshift:
  fips: true
```

1. Set this field to the instruction set architecture of the cluster nodes. Some examples include, **x86_64**, **aarch64**, or **ppc64le**.
2. Include this field if you want to use a Trusted Platform Module (TPM) to encrypt the root file system.
3. Include this section if you want to use one or more Tang servers.
4. Specify the minimum number of TPM v2 and Tang encryption conditions that must be met for decryption to occur.



IMPORTANT

The default **threshold** value is **1**. If you include multiple encryption conditions in your configuration but do not specify a threshold, decryption can occur if any of the conditions are met.

NOTE

If you require both TPM v2 and Tang for decryption, the value of the **threshold** attribute must equal the total number of stated Tang servers plus one. If the **threshold** value is lower, it is possible for the threshold to be reached by using one of the encryption modes only. For example, if **tpm2** is set to **true** and you specify two Tang servers, a threshold of **2** can be met by accessing the two Tang servers even if the TPM secure cryptoprocessor is not available.

24.1.4.2. About disk mirroring

During OpenShift Container Platform installation on control plane and worker nodes, you can enable mirroring of the boot and other disks to two or more redundant storage devices. A node continues to function after storage device failure as long as one device remains available.

Mirroring does not support replacement of a failed disk. To restore the mirror to a pristine, non-degraded state, reprovision the node.

NOTE

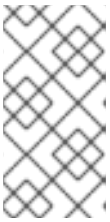
For user-provisioned infrastructure deployments, mirroring is available only on RHCOS systems. Support for mirroring is available on **x86_64** nodes booted with BIOS or UEFI and on **ppc64le** nodes.

24.1.4.3. Configuring disk encryption and mirroring

You can enable and configure encryption and mirroring during an OpenShift Container Platform installation.

Prerequisites

- You have downloaded the OpenShift Container Platform installation program on your installation node.
- You installed Butane on your installation node.



NOTE

Butane is a command-line utility that OpenShift Container Platform uses to provide convenient, short-hand syntax for writing machine configs, as well as for performing additional validation of machine configs. For more information, see the *Creating machine configs with Butane* section.

- You have access to a Red Hat Enterprise Linux (RHEL) 8 machine that can be used to generate a thumbprint of the Tang exchange key.

Procedure

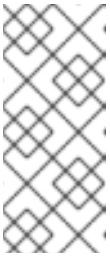
1. If you want to use TPM v2 to encrypt your cluster, check to see if TPM v2 encryption needs to be enabled in the BIOS on each node. This is required on most Dell systems. Check the manual for your computer.
2. If you want to use Tang to encrypt your cluster, follow these preparatory steps:
   a. Set up a Tang server or access an existing one. See Network-bound disk encryption for instructions.
   b. Install the **clevis** package on a RHEL 8 machine, if it is not already installed:

```
$ sudo yum install clevis
```

   c. On the RHEL 8 machine, run the following command to generate a thumbprint of the exchange key. Replace **http://tang.example.com:7500** with the URL of your Tang server:

```
$ clevis-encrypt-tang '{"url":"http://tang.example.com:7500"}' < /dev/null > /dev/null 1
```

1 In this example, **tangd.socket** is listening on port **7500** on the Tang server.



NOTE

The **clevis-encrypt-tang** command is used in this step only to generate a thumbprint of the exchange key. No data is being passed to the command for encryption at this point, so **/dev/null** is provided as an input instead of plain text. The encrypted output is also sent to **/dev/null**, because it is not required for this procedure.

Example output

```
The advertisement contains the following signing keys:

PLjNyRdGw03zlRoGjQYMahSZGu9 1
```

1 The thumbprint of the exchange key.

When the **Do you wish to trust these keys? [ynYN]** prompt displays, type **Y**.

NOTE

RHEL 8 provides Clevis version 15, which uses the SHA-1 hash algorithm to generate thumbprints. Some other distributions provide Clevis version 17 or later, which use the SHA-256 hash algorithm for thumbprints. You must use a Clevis version that uses SHA-1 to create the thumbprint, to prevent Clevis binding issues when you install Red Hat Enterprise Linux CoreOS (RHCOS) on your OpenShift Container Platform cluster nodes.

d. If the nodes are configured with static IP addressing, run **coreos-installer iso customize --dest-karg-append** or use the **coreos-installer --append-karg** option when installing RHCOS nodes to set the IP address of the installed system. Append the **ip=** and other arguments needed for your network.

IMPORTANT

Some methods for configuring static IPs do not affect the initramfs after the first boot and will not work with Tang encryption. These include the **coreos-installer --copy-network** option, the **coreos-installer iso customize --network-keyfile** option, and the **coreos-installer pxe customize --network-keyfile** option, as well as adding **ip=** arguments to the kernel command line of the live ISO or PXE image during installation. Incorrect static IP configuration causes the second boot of the node to fail.

3. On your installation node, change to the directory that contains the installation program and generate the Kubernetes manifests for the cluster:

```
$ ./openshift-install create manifests --dir <installation_directory> 1
```

1 Replace **<installation_directory>** with the path to the directory that you want to store the installation files in.

4. Create a Butane config that configures disk encryption, mirroring, or both. For example, to configure storage for compute nodes, create a **$HOME/clusterconfig/worker-storage.bu** file.

Butane config example for a boot device

```
variant: openshift
version: 4.11.0
metadata:
  name: worker-storage (1)
  labels:
    machineconfiguration.openshift.io/role: worker (2)
boot_device:
  layout: x86_64 (3)
  luks: (4)
    tpm2: true (5)
    tang: (6)
      - url: http://tang.example.com:7500 (7)
        thumbprint: PLjNyRdGw03zlRoGjQYMahSZGu9 (8)
    threshold: 1 (9)
  mirror: (10)
    devices: (11)
      - /dev/sda
      - /dev/sdb
openshift:
  fips: true (12)
```

(1) (2) For control plane configurations, replace **worker** with **master** in both of these locations.

(3) Set this field to the instruction set architecture of the cluster nodes. Some examples include, **x86_64**, **aarch64**, or **ppc64le**.

(4) Include this section if you want to encrypt the root file system. For more details, see the *About disk encryption* section.

(5) Include this field if you want to use a Trusted Platform Module (TPM) to encrypt the root file system.

(6) Include this section if you want to use one or more Tang servers.

(7) Specify the URL of a Tang server. In this example, **tangd.socket** is listening on port **7500** on the Tang server.

(8) Specify the exchange key thumbprint, which was generated in a preceding step.

(9) Specify the minimum number of TPM v2 and Tang encryption conditions that must be met for decryption to occur. The default value is **1**. For more information on this topic, see the *Configuring an encryption threshold* section.

(10) Include this section if you want to mirror the boot disk. For more details, see *About disk mirroring*.

(11) List all disk devices that should be included in the boot disk mirror, including the disk that RHCOS will be installed onto.

(12) Include this directive to enable FIPS mode on your cluster.

IMPORTANT

To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode . If you are configuring nodes to use both disk encryption and mirroring, both features must be configured in the same Butane configuration file. In addition, if you are configuring disk encryption on a node with FIPS mode enabled, you must include the **fips** directive in the same Butane configuration file, even if FIPS mode is also enabled in a separate manifest.

5. Create a control plane or compute node manifest from the corresponding Butane configuration file and save it to the **<installation_directory>/openshift** directory. For example, to create a manifest for the compute nodes, run the following command:

```
$ butane $HOME/clusterconfig/worker-storage.bu -o <installation_directory>/openshift/99-worker-storage.yaml
```

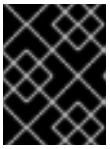
   Repeat this step for each node type that requires disk encryption or mirroring.

6. Save the Butane configuration file in case you need to update the manifests in the future.

7. Continue with the remainder of the OpenShift Container Platform installation.

TIP

You can monitor the console log on the RHCOS nodes during installation for error messages relating to disk encryption or mirroring.



IMPORTANT

If you configure additional data partitions, they will not be encrypted unless encryption is explicitly requested.

Verification

After installing OpenShift Container Platform, you can verify if boot disk encryption or mirroring is enabled on the cluster nodes.

1. From the installation host, access a cluster node by using a debug pod:

   a. Start a debug pod for the node. The following example starts a debug pod for the **compute-1** node:

```
$ oc debug node/compute-1
```

   b. Set **/host** as the root directory within the debug shell. The debug pod mounts the root file system of the node in **/host** within the pod. By changing the root directory to **/host**, you can run binaries contained in the executable paths on the node:

```
# chroot /host
```

NOTE

OpenShift Container Platform cluster nodes running Red Hat Enterprise Linux CoreOS (RHCOS) are immutable and rely on Operators to apply cluster changes. Accessing cluster nodes using SSH is not recommended. However, if the OpenShift Container Platform API is not available, or **kubelet** is not properly functioning on the target node, **oc** operations will be impacted. In such situations, it is possible to access nodes using **ssh core@<node>.<cluster_name>.<base_domain>** instead.

2. If you configured boot disk encryption, verify if it is enabled:

   a. From the debug shell, review the status of the root mapping on the node:

   ```
   # cryptsetup status root
   ```

   Example output

   ```
   /dev/mapper/root is active and is in use.
     type:    LUKS2 1
     cipher:  aes-xts-plain64 2
     keysize: 512 bits
     key location: keyring
     device:  /dev/sda4 3
     sector size:  512
     offset:  32768 sectors
     size:    15683456 sectors
     mode:    read/write
   ```

   1. The encryption format. When the TPM v2 or Tang encryption modes are enabled, the RHCOS boot disks are encrypted using the LUKS2 format.
   2. The encryption algorithm used to encrypt the LUKS2 volume. The **aes-cbc-essiv:sha256** cipher is used if FIPS mode is enabled.
   3. The device that contains the encrypted LUKS2 volume. If mirroring is enabled, the value will represent a software mirror device, for example **/dev/md126**.

   b. List the Clevis plugins that are bound to the encrypted device:

   ```
   # clevis luks list -d /dev/sda4 1
   ```

   1. Specify the device that is listed in the **device** field in the output of the preceding step.

   Example output

   ```
   1: sss '{"t":1,"pins":{"tang":[{"url":"http://tang.example.com:7500"}]}}' 1
   ```

   1. In the example output, the Tang plugin is used by the Shamir's Secret Sharing (SSS) Clevis plugin for the **/dev/sda4** device.

3. If you configured mirroring, verify if it is enabled:

   a. From the debug shell, list the software RAID devices on the node:

   ```
   # cat /proc/mdstat
   ```

   Example output

   ```
   Personalities : [raid1]
   md126 : active raid1 sdb3[1] sda3[0] (1)
     393152 blocks super 1.0 [2/2] [UU]

   md127 : active raid1 sda4[0] sdb4[1] (2)
     51869632 blocks super 1.2 [2/2] [UU]

   unused devices: <none>
   ```

   (1) In the example, the **/dev/md126** software RAID mirror device uses the **/dev/sda3** and **/dev/sdb3** disk devices on the cluster node.

   (2) In the example, the **/dev/md127** software RAID mirror device uses the **/dev/sda4** and **/dev/sdb4** disk devices on the cluster node.

   b. Review the details of each of the software RAID devices listed in the output of the preceding command. The following example lists the details of the **/dev/md126** device:

   ```
   # mdadm --detail /dev/md126
   ```

   Example output

   ```
   /dev/md126:
              Version : 1.0
        Creation Time : Wed Jul  7 11:07:36 2021
           Raid Level : raid1 (1)
           Array Size : 393152 (383.94 MiB 402.59 MB)
        Used Dev Size : 393152 (383.94 MiB 402.59 MB)
         Raid Devices : 2
        Total Devices : 2
          Persistence : Superblock is persistent

          Update Time : Wed Jul  7 11:18:24 2021
                State : clean (2)
       Active Devices : 2 (3)
      Working Devices : 2 (4)
       Failed Devices : 0 (5)
        Spare Devices : 0

   Consistency Policy : resync

                 Name : any:md-boot (6)
                 UUID : ccfa3801:c520e0b5:2bee2755:69043055
               Events : 19
   ```

```
Number   Major   Minor   RaidDevice State
   0     252       3        0      active sync   /dev/sda3 7
   1     252      19        1      active sync   /dev/sdb3 8
```

1 Specifies the RAID level of the device. **raid1** indicates RAID 1 disk mirroring.

2 Specifies the state of the RAID device.

3 4 States the number of underlying disk devices that are active and working.

5 States the number of underlying disk devices that are in a failed state.

6 The name of the software RAID device.

7 8 Provides information about the underlying disk devices that are used by the software RAID device.

c. List the file systems that are mounted on the software RAID devices:

```
# mount | grep /dev/md
```

Example output

```
/dev/md127 on / type xfs
(rw,relatime,seclabel,attr2,inode64,logbufs=8,logbsize=32k,prjquota)
/dev/md127 on /etc type xfs
(rw,relatime,seclabel,attr2,inode64,logbufs=8,logbsize=32k,prjquota)
/dev/md127 on /usr type xfs
(ro,relatime,seclabel,attr2,inode64,logbufs=8,logbsize=32k,prjquota)
/dev/md127 on /sysroot type xfs
(ro,relatime,seclabel,attr2,inode64,logbufs=8,logbsize=32k,prjquota)
/dev/md127 on /var type xfs
(rw,relatime,seclabel,attr2,inode64,logbufs=8,logbsize=32k,prjquota)
/dev/md127 on /var/lib/containers/storage/overlay type xfs
(rw,relatime,seclabel,attr2,inode64,logbufs=8,logbsize=32k,prjquota)
/dev/md127 on /var/lib/kubelet/pods/e5054ed5-f882-4d14-b599-99c050d4e0c0/volume-
subpaths/etc/tuned/1 type xfs
(rw,relatime,seclabel,attr2,inode64,logbufs=8,logbsize=32k,prjquota)
/dev/md127 on /var/lib/kubelet/pods/e5054ed5-f882-4d14-b599-99c050d4e0c0/volume-
subpaths/etc/tuned/2 type xfs
(rw,relatime,seclabel,attr2,inode64,logbufs=8,logbsize=32k,prjquota)
/dev/md127 on /var/lib/kubelet/pods/e5054ed5-f882-4d14-b599-99c050d4e0c0/volume-
subpaths/etc/tuned/3 type xfs
(rw,relatime,seclabel,attr2,inode64,logbufs=8,logbsize=32k,prjquota)
/dev/md127 on /var/lib/kubelet/pods/e5054ed5-f882-4d14-b599-99c050d4e0c0/volume-
subpaths/etc/tuned/4 type xfs
(rw,relatime,seclabel,attr2,inode64,logbufs=8,logbsize=32k,prjquota)
/dev/md127 on /var/lib/kubelet/pods/e5054ed5-f882-4d14-b599-99c050d4e0c0/volume-
subpaths/etc/tuned/5 type xfs
(rw,relatime,seclabel,attr2,inode64,logbufs=8,logbsize=32k,prjquota)
/dev/md126 on /boot type ext4 (rw,relatime,seclabel)
```

In the example output, the **/boot** file system is mounted on the **/dev/md126** software RAID device and the root file system is mounted on **/dev/md127**.

4. Repeat the verification steps for each OpenShift Container Platform node type.

Additional resources

- For more information about the TPM v2 and Tang encryption modes, see Configuring automated unlocking of encrypted volumes using policy-based decryption.

24.1.4.4. Configuring a RAID-enabled data volume

You can enable software RAID partitioning to provide an external data volume. OpenShift Container Platform supports RAID 0, RAID 1, RAID 4, RAID 5, RAID 6, and RAID 10 for data protection and fault tolerance. See "About disk mirroring" for more details.

Prerequisites

- You have downloaded the OpenShift Container Platform installation program on your installation node.
- You have installed Butane on your installation node.

NOTE

Butane is a command-line utility that OpenShift Container Platform uses to provide convenient, short-hand syntax for writing machine configs, as well as for performing additional validation of machine configs. For more information, see the *Creating machine configs with Butane* section.

Procedure

1. Create a Butane config that configures a data volume by using software RAID.
   - To configure a data volume with RAID 1 on the same disks that are used for a mirrored boot disk, create a **$HOME/clusterconfig/raid1-storage.bu** file, for example:

     RAID 1 on mirrored boot disk

```
variant: openshift
version: 4.11.0
metadata:
  name: raid1-storage
  labels:
    machineconfiguration.openshift.io/role: worker
boot_device:
  mirror:
    devices:
      - /dev/sda
      - /dev/sdb
storage:
  disks:
    - device: /dev/sda
      partitions:
        - label: root-1
          size_mib: 25000 (1)
        - label: var-1
    - device: /dev/sdb
```

```
      partitions:
        - label: root-2
          size_mib: 25000 2
        - label: var-2
  raid:
    - name: md-var
      level: raid1
      devices:
        - /dev/disk/by-partlabel/var-1
        - /dev/disk/by-partlabel/var-2
  filesystems:
    - device: /dev/md/md-var
      path: /var
      format: xfs
      wipe_filesystem: true
      with_mount_unit: true
```

1 2 When adding a data partition to the boot disk, a minimum value of 25000 mebibytes is recommended. If no value is specified, or if the specified value is smaller than the recommended minimum, the resulting root file system will be too small, and future reinstalls of RHCOS might overwrite the beginning of the data partition.

- To configure a data volume with RAID 1 on secondary disks, create a **$HOME/clusterconfig/raid1-alt-storage.bu** file, for example:

  RAID 1 on secondary disks

```
variant: openshift
version: 4.11.0
metadata:
  name: raid1-alt-storage
  labels:
    machineconfiguration.openshift.io/role: worker
storage:
  disks:
    - device: /dev/sdc
      wipe_table: true
      partitions:
        - label: data-1
    - device: /dev/sdd
      wipe_table: true
      partitions:
        - label: data-2
  raid:
    - name: md-var-lib-containers
      level: raid1
      devices:
        - /dev/disk/by-partlabel/data-1
        - /dev/disk/by-partlabel/data-2
  filesystems:
    - device: /dev/md/md-var-lib-containers
      path: /var/lib/containers
      format: xfs
      wipe_filesystem: true
      with_mount_unit: true
```

2. Create a RAID manifest from the Butane config you created in the previous step and save it to the **<installation_directory>/openshift** directory. For example, to create a manifest for the compute nodes, run the following command:

```
$ butane $HOME/clusterconfig/<butane_config>.bu -o
<installation_directory>/openshift/<manifest_name>.yaml 1
```

1 Replace **<butane_config>** and **<manifest_name>** with the file names from the previous step. For example, **raid1-alt-storage.bu** and **raid1-alt-storage.yaml** for secondary disks.

3. Save the Butane config in case you need to update the manifest in the future.

4. Continue with the remainder of the OpenShift Container Platform installation.

24.1.5. Configuring chrony time service

You can set the time server and related settings used by the chrony time service (**chronyd**) by modifying the contents of the **chrony.conf** file and passing those contents to your nodes as a machine config.

Procedure

1. Create a Butane config including the contents of the **chrony.conf** file. For example, to configure chrony on worker nodes, create a **99-worker-chrony.bu** file.

NOTE

See "Creating machine configs with Butane" for information about Butane.

```
variant: openshift
version: 4.11.0
metadata:
  name: 99-worker-chrony 1
  labels:
    machineconfiguration.openshift.io/role: worker 2
storage:
  files:
  - path: /etc/chrony.conf
    mode: 0644 3
    overwrite: true
    contents:
      inline: |
        pool 0.rhel.pool.ntp.org iburst 4
        driftfile /var/lib/chrony/drift
        makestep 1.0 3
        rtcsync
        logdir /var/log/chrony
```

1 2 On control plane nodes, substitute **master** for **worker** in both of these locations.

3 Specify an octal value mode for the **mode** field in the machine config file. After creating

4 Specify any valid, reachable time source, such as the one provided by your DHCP server. Alternately, you can specify any of the following NTP servers: **1.rhel.pool.ntp.org**,

2. Use Butane to generate a **MachineConfig** object file, **99-worker-chrony.yaml**, containing the configuration to be delivered to the nodes:

```
$ butane 99-worker-chrony.bu -o 99-worker-chrony.yaml
```

3. Apply the configurations in one of two ways:

- If the cluster is not running yet, after you generate manifest files, add the **MachineConfig** object file to the **<installation_directory>/openshift** directory, and then continue to create the cluster.
- If the cluster is already running, apply the file:

```
$ oc apply -f ./99-worker-chrony.yaml
```

24.1.6. Additional resources

- For information on Butane, see Creating machine configs with Butane .
- For information on FIPS support, see Support for FIPS cryptography .

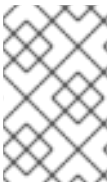
24.2. CONFIGURING YOUR FIREWALL

If you use a firewall, you must configure it so that OpenShift Container Platform can access the sites that it requires to function. You must always grant access to some sites, and you grant access to more if you use Red Hat Insights, the Telemetry service, a cloud to host your cluster, and certain build strategies.

24.2.1. Configuring your firewall for OpenShift Container Platform

Before you install OpenShift Container Platform, you must configure your firewall to grant access to the sites that OpenShift Container Platform requires.

There are no special configuration considerations for services running on only controller nodes compared to worker nodes.



NOTE

If your environment has a dedicated load balancer in front of your OpenShift Container Platform cluster, review the allowlists between your firewall and load balancer to prevent unwanted network restrictions to your cluster.

Procedure

1. Allowlist the following registry URLs:

URL	Port	Function
registry.redhat.io	443	Provides core container images

URL	Port	Function
access.redhat.com [1]	443	Hosts all the container images that are stored on the Red Hat Ecosytem Catalog, including core container images.
quay.io	443	Provides core container images
cdn.quay.io	443	Provides core container images
cdn01.quay.io	443	Provides core container images
cdn02.quay.io	443	Provides core container images
cdn03.quay.io	443	Provides core container images
sso.redhat.com	443	The **https://console.redhat.com** site uses authentication from **sso.redhat.com**

1. In a firewall environment, ensure that the **access.redhat.com** resource is on the allowlist. This resource hosts a signature store that a container client requires for verifying images when pulling them from **registry.access.redhat.com**.

You can use the wildcards ***.quay.io** and ***.openshiftapps.com** instead of **cdn.quay.io** and **cdn0[1-3].quay.io** in your allowlist. When you add a site, such as **quay.io**, to your allowlist, do not add a wildcard entry, such as ***.quay.io**, to your denylist. In most cases, image registries use a content delivery network (CDN) to serve images. If a firewall blocks access, image downloads are denied when the initial download request redirects to a hostname such as **cdn01.quay.io**.

2. Allowlist any site that provides resources for a language or framework that your builds require.

3. If you do not disable Telemetry, you must grant access to the following URLs to access Red Hat Insights:

URL	Port	Function
cert-api.access.redhat.com	443	Required for Telemetry
api.access.redhat.com	443	Required for Telemetry
infogw.api.openshift.com	443	Required for Telemetry
console.redhat.com	443	Required for Telemetry and for **insights-operator**

4. If you use Alibaba Cloud, Amazon Web Services (AWS), Microsoft Azure, or Google Cloud Platform (GCP) to host your cluster, you must grant access to the URLs that provide the cloud provider API and DNS for that cloud:

Cloud	URL	Port	Function
Alibaba	***.aliyuncs.com**	443	Required to access Alibaba Cloud services and resources. Review the Alibaba endpoints_config.go file to determine the exact endpoints to allow for the regions that you use.
AWS	***.amazonaws.com** Alternatively, if you choose to not use a wildcard for AWS APIs, you must allowlist the following URLs:	443	Required to access AWS services and resources. Review the AWS Service Endpoints in the AWS documentation to determine the exact endpoints to allow for the regions that you use.
	ec2.amazonaws.com	443	Used to install and manage clusters in an AWS environment.
	events.amazonaws.com	443	Used to install and manage clusters in an AWS environment.
	iam.amazonaws.com	443	Used to install and manage clusters in an AWS environment.
	route53.amazonaws.com	443	Used to install and manage clusters in an AWS environment.
	s3.amazonaws.com	443	Used to install and manage clusters in an AWS environment.
	s3.<aws_region>.amazonaws.com	443	Used to install and manage clusters in an AWS environment.
	s3.dualstack.<aws_region>.amazonaws.com	443	Used to install and manage clusters in an AWS environment.
	sts.amazonaws.com	443	Used to install and manage clusters in an AWS environment.
	sts.<aws_region>.amazonaws.com	443	Used to install and manage clusters in an AWS environment.
	tagging.us-east-1.amazonaws.com	443	Used to install and manage clusters in an AWS environment. This endpoint is always **us-east-1**, regardless of the region the cluster is deployed in.
	ec2.<aws_region>.amazonaws.com	443	Used to install and manage clusters in an AWS environment.

Cloud	URL	Port	Function
	elasticloadbalancing.<aws_region>.amazonaws.com	443	Used to install and manage clusters in an AWS environment.
	servicequotas.<aws_region>.amazonaws.com	443	Required. Used to confirm quotas for deploying the service.
	tagging.<aws_region>.amazonaws.com	443	Allows the assignment of metadata about AWS resources in the form of tags.
GCP	***.googleapis.com**	443	Required to access GCP services and resources. Review Cloud Endpoints in the GCP documentation to determine the endpoints to allow for your APIs.
	accounts.google.com	443	Required to access your GCP account.
Azure	**management.azure.com**	443	Required to access Azure services and resources. Review the Azure REST API reference in the Azure documentation to determine the endpoints to allow for your APIs.
	***.blob.core.windows.net**	443	Required to download Ignition files.
	login.microsoftonline.com	443	Required to access Azure services and resources. Review the Azure REST API reference in the Azure documentation to determine the endpoints to allow for your APIs.

5. Allowlist the following URLs:

URL	Port	Function
mirror.openshift.com	443	Required to access mirrored installation content and images. This site is also a source of release image signatures, although the Cluster Version Operator needs only a single functioning source.
storage.googleapis.com/openshift-release	443	A source of release image signatures, although the Cluster Version Operator needs only a single functioning source.

URL	Port	Function
***.apps.<cluster_name>.<base_domain>**	443	Required to access the default cluster routes unless you set an ingress wildcard during installation.
quayio-production-s3.s3.amazonaws.com	443	Required to access Quay image content in AWS.
api.openshift.com	443	Required both for your cluster token and to check if updates are available for the cluster.
rhcos.mirror.openshift.com	443	Required to download Red Hat Enterprise Linux CoreOS (RHCOS) images.
console.redhat.com	443	Required for your cluster token.
sso.redhat.com	443	The **https://console.redhat.com** site uses authentication from **sso.redhat.com**

Operators require route access to perform health checks. Specifically, the authentication and web console Operators connect to two routes to verify that the routes work. If you are the cluster administrator and do not want to allow ***.apps.<cluster_name>.<base_domain>**, then allow these routes:

- **oauth-openshift.apps.<cluster_name>.<base_domain>**
- **console-openshift-console.apps.<cluster_name>.<base_domain>**, or the hostname that is specified in the **spec.route.hostname** field of the **consoles.operator/cluster** object if the field is not empty.

6. Allowlist the following URLs for optional third-party content:

URL	Port	Function
registry.connect.redhat.com	443	Required for all third-party images and certified operators.
rhc4tp-prod-z8cxf-image-registry-us-east-1-evenkyleffocxqvofrk.s3.dualstack.us-east-1.amazonaws.com	443	Provides access to container images hosted on **registry.connect.redhat.com**
oso-rhc4tp-docker-registry.s3-us-west-2.amazonaws.com	443	Required for Sonatype Nexus, F5 Big IP operators.

7. If you use a default Red Hat Network Time Protocol (NTP) server allow the following URLs:

- **1.rhel.pool.ntp.org**
- **2.rhel.pool.ntp.org**
- **3.rhel.pool.ntp.org**

NOTE

If you do not use a default Red Hat NTP server, verify the NTP server for your platform and allow it in your firewall.

CHAPTER 25. VALIDATING AN INSTALLATION

You can check the status of an OpenShift Container Platform cluster after an installation by following the procedures in this document.

25.1. REVIEWING THE INSTALLATION LOG

You can review a summary of an installation in the OpenShift Container Platform installation log. If an installation succeeds, the information required to access the cluster is included in the log.

Prerequisites

- You have access to the installation host.

Procedure

- Review the **.openshift_install.log** log file in the installation directory on your installation host:

```
$ cat <install_dir>/.openshift_install.log
```

Example output

Cluster credentials are included at the end of the log if the installation is successful, as outlined in the following example:

```
...
time="2020-12-03T09:50:47Z" level=info msg="Install complete!"
time="2020-12-03T09:50:47Z" level=info msg="To access the cluster as the system:admin
user when using 'oc', run 'export KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'"
time="2020-12-03T09:50:47Z" level=info msg="Access the OpenShift web-console here:
https://console-openshift-console.apps.mycluster.example.com"
time="2020-12-03T09:50:47Z" level=info msg="Login to the console with user: \"kubeadmin\",
and password: \"password\""
time="2020-12-03T09:50:47Z" level=debug msg="Time elapsed per stage:"
time="2020-12-03T09:50:47Z" level=debug msg="    Infrastructure: 6m45s"
time="2020-12-03T09:50:47Z" level=debug msg="Bootstrap Complete: 11m30s"
time="2020-12-03T09:50:47Z" level=debug msg=" Bootstrap Destroy: 1m5s"
time="2020-12-03T09:50:47Z" level=debug msg=" Cluster Operators: 17m31s"
time="2020-12-03T09:50:47Z" level=info msg="Time elapsed: 37m26s"
```

25.2. VIEWING THE IMAGE PULL SOURCE

For clusters with unrestricted network connectivity, you can view the source of your pulled images by using a command on a node, such as **crictl images**.

However, for disconnected installations, to view the source of pulled images, you must review the CRI-O logs to locate the **Trying to access** log entry, as shown in the following procedure. Other methods to view the image pull source, such as the **crictl images** command, show the non-mirrored image name, even though the image is pulled from the mirrored location.

Prerequisites

- You have access to the cluster as a user with the **cluster-admin** role.

Procedure

- Review the CRI-O logs for a master or worker node:

```
$  oc adm node-logs <node_name> -u crio
```

Example output

The **Trying to access** log entry indicates where the image is being pulled from.

```
...
Mar 17 02:52:50 ip-10-0-138-140.ec2.internal crio[1366]: time="2021-08-05
10:33:21.594930907Z" level=info msg="Pulling image: quay.io/openshift-release-dev/ocp-
release:4.10.0-ppc64le" id=abcd713b-d0e1-4844-ac1c-474c5b60c07c
name=/runtime.v1alpha2.ImageService/PullImage
Mar 17 02:52:50 ip-10-0-138-140.ec2.internal crio[1484]: time="2021-03-17
02:52:50.194341109Z" level=info msg="Trying to access \"li0317gcp1.mirror-
registry.qe.gcp.devcluster.openshift.com:5000/ocp/release@sha256:1926eae7cacb9c00f142ec
98b00628970e974284b6ddaf9a6a086cb9af7a6c31\""
Mar 17 02:52:50 ip-10-0-138-140.ec2.internal crio[1484]: time="2021-03-17
02:52:50.226788351Z" level=info msg="Trying to access \"li0317gcp1.mirror-
registry.qe.gcp.devcluster.openshift.com:5000/ocp/release@sha256:1926eae7cacb9c00f142ec
98b00628970e974284b6ddaf9a6a086cb9af7a6c31\""
...
```

The log might show the image pull source twice, as shown in the preceding example.

If your **ImageContentSourcePolicy** object lists multiple mirrors, OpenShift Container Platform attempts to pull the images in the order listed in the configuration, for example:

```
Trying to access \"li0317gcp1.mirror-
registry.qe.gcp.devcluster.openshift.com:5000/ocp/release@sha256:1926eae7cacb9c00f142ec
98b00628970e974284b6ddaf9a6a086cb9af7a6c31\"
Trying to access \"li0317gcp2.mirror-
registry.qe.gcp.devcluster.openshift.com:5000/ocp/release@sha256:1926eae7cacb9c00f142ec
98b00628970e974284b6ddaf9a6a086cb9af7a6c31\"
```

25.3. GETTING CLUSTER VERSION, STATUS, AND UPDATE DETAILS

You can view the cluster version and status by running the **oc get clusterversion** command. If the status shows that the installation is still progressing, you can review the status of the Operators for more information.

You can also list the current update channel and review the available cluster updates.

Prerequisites

- You have access to the cluster as a user with the **cluster-admin** role.
- You have installed the OpenShift CLI (**oc**).

Procedure

1. Obtain the cluster version and overall status:

```
$ oc get clusterversion
```

Example output

```
NAME      VERSION   AVAILABLE   PROGRESSING   SINCE   STATUS
version   4.6.4     True        False         6m25s   Cluster version is 4.6.4
```

The example output indicates that the cluster has been installed successfully.

2. If the cluster status indicates that the installation is still progressing, you can obtain more detailed progress information by checking the status of the Operators:

```
$ oc get clusteroperators.config.openshift.io
```

3. View a detailed summary of cluster specifications, update availability, and update history:

```
$ oc describe clusterversion
```

4. List the current update channel:

```
$ oc get clusterversion -o jsonpath='{.items[0].spec}{"\n"}'
```

Example output

```
{"channel":"stable-4.6","clusterID":"245539c1-72a3-41aa-9cec-72ed8cf25c5c"}
```

5. Review the available cluster updates:

```
$ oc adm upgrade
```

Example output

```
Cluster version is 4.6.4

Updates:

VERSION IMAGE
4.6.6   quay.io/openshift-release-dev/ocp-release@sha256:c7e8f18e8116356701bd23ae3a23fb9892dd5ea66c8300662ef30563d7104f39
```

Additional resources

- See Querying Operator status after installation for more information about querying Operator status if your installation is still progressing.
- See Troubleshooting Operator issues for information about investigating issues with Operators.
- See Updating a cluster between minor versions for more information on updating your cluster.
- See Understanding update channels and releases for an overview about update release channels.

25.4. QUERYING THE STATUS OF THE CLUSTER NODES BY USING THE CLI

You can verify the status of the cluster nodes after an installation.

Prerequisites

- You have access to the cluster as a user with the **cluster-admin** role.
- You have installed the OpenShift CLI (**oc**).

Procedure

1. List the status of the cluster nodes. Verify that the output lists all of the expected control plane and compute nodes and that each node has a **Ready** status:

```
$ oc get nodes
```

Example output

```
NAME                         STATUS   ROLES    AGE   VERSION
compute-1.example.com        Ready    worker   33m   v1.24.0
control-plane-1.example.com  Ready    master   41m   v1.24.0
control-plane-2.example.com  Ready    master   45m   v1.24.0
compute-2.example.com        Ready    worker   38m   v1.24.0
compute-3.example.com        Ready    worker   33m   v1.24.0
control-plane-3.example.com  Ready    master   41m   v1.24.0
```

2. Review CPU and memory resource availability for each cluster node:

```
$ oc adm top nodes
```

Example output

```
NAME                         CPU(cores)   CPU%   MEMORY(bytes)   MEMORY%
compute-1.example.com        128m         8%     1132Mi          16%
control-plane-1.example.com  801m         22%    3471Mi          23%
control-plane-2.example.com  1718m        49%    6085Mi          40%
compute-2.example.com        935m         62%    5178Mi          75%
compute-3.example.com        111m         7%     1131Mi          16%
control-plane-3.example.com  942m         26%    4100Mi          27%
```

Additional resources

- See Verifying node health for more details about reviewing node health and investigating node issues.

25.5. REVIEWING THE CLUSTER STATUS FROM THE OPENSHIFT CONTAINER PLATFORM WEB CONSOLE

You can review the following information in the **Overview** page in the OpenShift Container Platform web console:

- The general status of your cluster
- The status of the control plane, cluster Operators, and storage
- CPU, memory, file system, network transfer, and pod availability
- The API address of the cluster, the cluster ID, and the name of the provider
- Cluster version information
- Cluster update status, including details of the current update channel and available updates
- A cluster inventory detailing node, pod, storage class, and persistent volume claim (PVC) information
- A list of ongoing cluster activities and recent events

Prerequisites

- You have access to the cluster as a user with the **cluster-admin** role.

Procedure

- In the **Administrator** perspective, navigate to **Home → Overview**.

25.6. REVIEWING THE CLUSTER STATUS FROM RED HAT OPENSHIFT CLUSTER MANAGER

From the OpenShift Container Platform web console, you can review detailed information about the status of your cluster on OpenShift Cluster Manager.

Prerequisites

- You have access to the cluster as a user with the **cluster-admin** role.

Procedure

1. In the **Administrator** perspective, navigate to **Home → Overview → Details → Cluster ID → OpenShift Cluster Manager** to open your cluster's **Overview** tab in the OpenShift Cluster Manager web console.
2. From the **Overview** tab on OpenShift Cluster Manager Hybrid Cloud Console , review the following information about your cluster:
   - vCPU and memory availability and resource usage
   - The cluster ID, status, type, region, and the provider name
   - Node counts by node type
   - Cluster version details, the creation date of the cluster, and the name of the cluster owner
   - The life cycle support status of the cluster

- Subscription information, including the service level agreement (SLA) status, the subscription unit type, the production status of the cluster, the subscription obligation, and the service level

  TIP

  To view the history for your cluster, click the **Cluster history** tab.

3. Navigate to the **Monitoring** page to review the following information:
   - A list of any issues that have been detected
   - A list of alerts that are firing
   - The cluster Operator status and version
   - The cluster's resource usage
4. Optional: You can view information about your cluster that Red Hat Insights collects by navigating to the **Overview** menu. From this menu you can view the following information:
   - Potential issues that your cluster might be exposed to, categorized by risk level
   - Health-check status by category

Additional resources

- See Using Insights to identify issues with your cluster for more information about reviewing potential issues with your cluster.

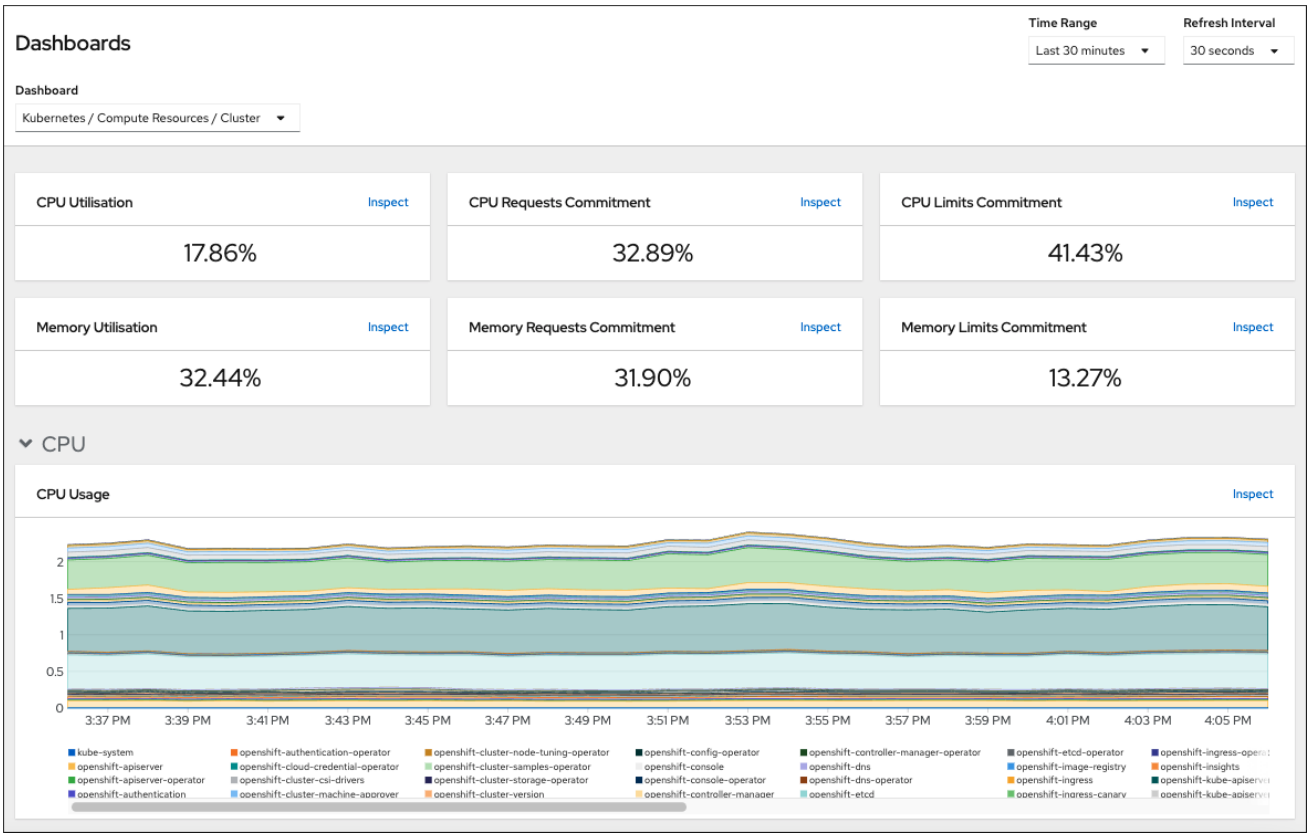
25.7. CHECKING CLUSTER RESOURCE AVAILABILITY AND UTILIZATION

OpenShift Container Platform provides a comprehensive set of monitoring dashboards that help you understand the state of cluster components.

In the **Administrator** perspective, you can access dashboards for core OpenShift Container Platform components, including:

- etcd
- Kubernetes compute resources
- Kubernetes network resources
- Prometheus
- Dashboards relating to cluster and node performance

Figure 25.1. Example compute resources dashboard



Prerequisites

- You have access to the cluster as a user with the **cluster-admin** role.

Procedure

1. In the **Administrator** perspective in the OpenShift Container Platform web console, navigate to **Observe → Dashboards**.
2. Choose a dashboard in the **Dashboard** list. Some dashboards, such as the **etcd** dashboard, produce additional sub-menus when selected.
3. Optional: Select a time range for the graphs in the **Time Range** list.
   - Select a pre-defined time period.
   - Set a custom time range by selecting **Custom time range** in the **Time Range** list.
     a. Input or select the **From** and **To** dates and times.
     b. Click **Save** to save the custom time range.
4. Optional: Select a **Refresh Interval**
5. Hover over each of the graphs within a dashboard to display detailed information about specific items.

Additional resources

- See Monitoring overview for more information about the OpenShift Container Platform monitoring stack.

25.8. LISTING ALERTS THAT ARE FIRING

Alerts provide notifications when a set of defined conditions are true in an OpenShift Container Platform cluster. You can review the alerts that are firing in your cluster by using the Alerting UI in the OpenShift Container Platform web console.

Prerequisites

- You have access to the cluster as a user with the **cluster-admin** role.

Procedure

1. In the **Administrator** perspective, navigate to the **Observe → Alerting → Alerts** page.
2. Review the alerts that are firing, including their **Severity**, **State**, and **Source**.
3. Select an alert to view more detailed information in the **Alert Details** page.

Additional resources

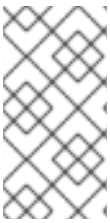
- See Managing alerts for further details about alerting in OpenShift Container Platform.

25.9. NEXT STEPS

- See Troubleshooting installations if you experience issues when installing your cluster.
- After installing OpenShift Container Platform, you can further expand and customize your cluster.

CHAPTER 26. TROUBLESHOOTING INSTALLATION ISSUES

To assist in troubleshooting a failed OpenShift Container Platform installation, you can gather logs from the bootstrap and control plane machines. You can also get debug information from the installation program. If you are unable to resolve the issue using the logs and debug information, see Determining where installation issues occur for component-specific troubleshooting.



NOTE

If your OpenShift Container Platform installation fails and the debug output or logs contain network timeouts or other connectivity errors, review the guidelines for configuring your firewall. Gathering logs from your firewall and load balancer can help you diagnose network-related errors.

26.1. PREREQUISITES

- You attempted to install an OpenShift Container Platform cluster and the installation failed.

26.2. GATHERING LOGS FROM A FAILED INSTALLATION

If you gave an SSH key to your installation program, you can gather data about your failed installation.

NOTE

You use a different command to gather logs about an unsuccessful installation than to gather logs from a running cluster. If you must gather logs from a running cluster, use the **oc adm must-gather** command.

Prerequisites

- Your OpenShift Container Platform installation failed before the bootstrap process finished. The bootstrap node is running and accessible through SSH.
- The **ssh-agent** process is active on your computer, and you provided the same SSH key to both the **ssh-agent** process and the installation program.
- If you tried to install a cluster on infrastructure that you provisioned, you must have the fully qualified domain names of the bootstrap and control plane nodes.

Procedure

1. Generate the commands that are required to obtain the installation logs from the bootstrap and control plane machines:
   - If you used installer-provisioned infrastructure, change to the directory that contains the installation program and run the following command:

```
$ ./openshift-install gather bootstrap --dir <installation_directory> 1
```

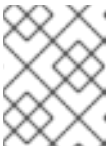
1 **installation_directory** is the directory you specified when you ran **./openshift-install create cluster**. This directory contains the OpenShift Container Platform definition files that the installation program creates.

For installer-provisioned infrastructure, the installation program stores information about the cluster, so you do not specify the hostnames or IP addresses.

- If you used infrastructure that you provisioned yourself, change to the directory that contains the installation program and run the following command:

```
$ ./openshift-install gather bootstrap --dir <installation_directory> \ 1
    --bootstrap <bootstrap_address> \ 2
    --master <master_1_address> \ 3
    --master <master_2_address> \ 4
    --master <master_3_address>" 5
```

1. For **installation_directory**, specify the same directory you specified when you ran **./openshift-install create cluster**. This directory contains the OpenShift Container Platform definition files that the installation program creates.
2. **<bootstrap_address>** is the fully qualified domain name or IP address of the cluster's bootstrap machine.
3. 4. 5. For each control plane, or master, machine in your cluster, replace **<master_*_address>** with its fully qualified domain name or IP address.



NOTE

A default cluster contains three control plane machines. List all of your control plane machines as shown, no matter how many your cluster uses.

Example output

```
INFO Pulling debug logs from the bootstrap machine
INFO Bootstrap gather logs captured here "<installation_directory>/log-bundle-
<timestamp>.tar.gz"
```

If you open a Red Hat support case about your installation failure, include the compressed logs in the case.

26.3. MANUALLY GATHERING LOGS WITH SSH ACCESS TO YOUR HOST(S)

Manually gather logs in situations where **must-gather** or automated collection methods do not work.

IMPORTANT

By default, SSH access to the OpenShift Container Platform nodes is disabled on the Red Hat OpenStack Platform (RHOSP) based installations.

Prerequisites

- You must have SSH access to your host(s).

Procedure

1. Collect the **bootkube.service** service logs from the bootstrap host using the **journalctl** command by running:

```
$ journalctl -b -f -u bootkube.service
```

2. Collect the bootstrap host's container logs using the podman logs. This is shown as a loop to get all of the container logs from the host:

```
$ for pod in $(sudo podman ps -a -q); do sudo podman logs $pod; done
```

3. Alternatively, collect the host's container logs using the **tail** command by running:

```
# tail -f /var/lib/containers/storage/overlay-containers/*/userdata/ctr.log
```

4. Collect the **kubelet.service** and **crio.service** service logs from the master and worker hosts using the **journalctl** command by running:

```
$ journalctl -b -f -u kubelet.service -u crio.service
```

5. Collect the master and worker host container logs using the **tail** command by running:

```
$ sudo tail -f /var/log/containers/*
```

26.4. MANUALLY GATHERING LOGS WITHOUT SSH ACCESS TO YOUR HOST(S)

Manually gather logs in situations where **must-gather** or automated collection methods do not work.

If you do not have SSH access to your node, you can access the systems journal to investigate what is happening on your host.

Prerequisites

- Your OpenShift Container Platform installation must be complete.
- Your API service is still functional.
- You have system administrator privileges.

Procedure

1. Access **journald** unit logs under **/var/log** by running:

```
$ oc adm node-logs --role=master -u kubelet
```

2. Access host file paths under **/var/log** by running:

```
$ oc adm node-logs --role=master --path=openshift-apiserver
```

26.5. GETTING DEBUG INFORMATION FROM THE INSTALLATION PROGRAM

You can use any of the following actions to get debug information from the installation program.

- Look at debug messages from a past installation in the hidden **.openshift_install.log** file. For example, enter:

```
$ cat ~/<installation_directory>/.openshift_install.log 1
```

1 For **installation_directory**, specify the same directory you specified when you ran **./openshift-install create cluster**.

- Change to the directory that contains the installation program and re-run it with **--log-level=debug**:

```
$ ./openshift-install create cluster --dir <installation_directory> --log-level debug 1
```

1 For **installation_directory**, specify the same directory you specified when you ran **./openshift-install create cluster**.

26.6. REINSTALLING THE OPENSHIFT CONTAINER PLATFORM CLUSTER

If you are unable to debug and resolve issues in the failed OpenShift Container Platform installation, consider installing a new OpenShift Container Platform cluster. Before starting the installation process again, you must complete thorough cleanup. For a user-provisioned infrastructure (UPI) installation, you must manually destroy the cluster and delete all associated resources. The following procedure is for an installer-provisioned infrastructure (IPI) installation.

Procedure

1. Destroy the cluster and remove all the resources associated with the cluster, including the hidden installer state files in the installation directory:

```
$ ./openshift-install destroy cluster --dir <installation_directory> 1
```

1 **installation_directory** is the directory you specified when you ran **./openshift-install create cluster**. This directory contains the OpenShift Container Platform definition files that the installation program creates.

2. Before reinstalling the cluster, delete the installation directory:

```
$ rm -rf <installation_directory>
```

3. Follow the procedure for installing a new OpenShift Container Platform cluster.

Additional resources

- Installing an OpenShift Container Platform cluster

CHAPTER 27. SUPPORT FOR FIPS CRYPTOGRAPHY

You can install an OpenShift Container Platform cluster that uses FIPS validated or Modules In Process cryptographic libraries on the **x86_64** architecture.

IMPORTANT

To enable FIPS mode for your cluster, you must run the installation program from a RHEL 8 computer that is configured to operate in FIPS mode. Running RHEL 9 with FIPS mode enabled to install an OpenShift Container Platform cluster is not possible.

For more information about configuring FIPS mode on RHEL, see Installing the system in FIPS mode.

For the Red Hat Enterprise Linux CoreOS (RHCOS) machines in your cluster, this change is applied when the machines are deployed based on the status of an option in the **install-config.yaml** file, which governs the cluster options that a user can change during cluster deployment. With Red Hat Enterprise Linux (RHEL) machines, you must enable FIPS mode when you install the operating system on the machines that you plan to use as worker machines. These configuration methods ensure that your cluster meet the requirements of a FIPS compliance audit: only FIPS validated or Modules In Process cryptography packages are enabled before the initial system boot.

Because FIPS must be enabled before the operating system that your cluster uses boots for the first time, you cannot enable FIPS after you deploy a cluster.

27.1. FIPS VALIDATION IN OPENSHIFT CONTAINER PLATFORM

OpenShift Container Platform uses certain FIPS validated or Modules In Process modules within RHEL and RHCOS for the operating system components that it uses. See RHEL8 core crypto components. For example, when users use SSH to connect to OpenShift Container Platform clusters and containers, those connections are properly encrypted.

OpenShift Container Platform components are written in Go and built with Red Hat's golang compiler. When you enable FIPS mode for your cluster, all OpenShift Container Platform components that require cryptographic signing call RHEL and RHCOS cryptographic libraries.

Table 27.1. FIPS mode attributes and limitations in OpenShift Container Platform 4.11

Attributes	Limitations
FIPS support in RHEL 8 and RHCOS operating systems.	The FIPS implementation does not offer a single function that both computes hash functions and validates the keys that are based on that hash. This limitation will continue to be evaluated and improved in future OpenShift Container Platform releases.
FIPS support in CRI-O runtimes.	
FIPS support in OpenShift Container Platform services.	
FIPS validated or Modules In Process cryptographic module and algorithms that are obtained from RHEL 8 and RHCOS binaries and images.	

Attributes	Limitations
Use of FIPS compatible golang compiler.	TLS FIPS support is not complete but is planned for future OpenShift Container Platform releases.
FIPS support across multiple architectures.	FIPS is currently only supported on OpenShift Container Platform deployments using the **x86_64** architecture.

27.2. FIPS SUPPORT IN COMPONENTS THAT THE CLUSTER USES

Although the OpenShift Container Platform cluster itself uses FIPS validated or Modules In Process modules, ensure that the systems that support your OpenShift Container Platform cluster use FIPS validated or Modules In Process modules for cryptography.

27.2.1. etcd

To ensure that the secrets that are stored in etcd use FIPS validated or Modules In Process encryption, boot the node in FIPS mode. After you install the cluster in FIPS mode, you can encrypt the etcd data by using the FIPS-approved **aes cbc** cryptographic algorithm.

27.2.2. Storage

For local storage, use RHEL-provided disk encryption or Container Native Storage that uses RHEL-provided disk encryption. By storing all data in volumes that use RHEL-provided disk encryption and enabling FIPS mode for your cluster, both data at rest and data in motion, or network data, are protected by FIPS validated or Modules In Process encryption. You can configure your cluster to encrypt the root filesystem of each node, as described in Customizing nodes.

27.2.3. Runtimes

To ensure that containers know that they are running on a host that is using FIPS validated or Modules In Process cryptography modules, use CRI-O to manage your runtimes. CRI-O supports FIPS mode, in that it configures the containers to know that they are running in FIPS mode.

27.3. INSTALLING A CLUSTER IN FIPS MODE

To install a cluster in FIPS mode, follow the instructions to install a customized cluster on your preferred infrastructure. Ensure that you set **fips: true** in the **install-config.yaml** file before you deploy your cluster.

- Amazon Web Services
- Alibaba Cloud
- Microsoft Azure
- Bare metal
- Google Cloud Platform

- Red Hat OpenStack Platform (RHOSP)
- VMware vSphere

NOTE

If you are using Azure File storage, you cannot enable FIPS mode.

To apply **AES CBC** encryption to your etcd data store, follow the Encrypting etcd data process after you install your cluster.

If you add RHEL nodes to your cluster, ensure that you enable FIPS mode on the machines before their initial boot. See Adding RHEL compute machines to an OpenShift Container Platform cluster and Enabling FIPS Mode in the RHEL 8 documentation.